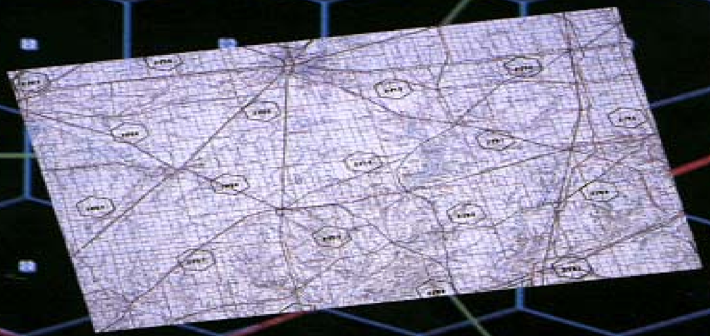
Landscape models to predict nutrients, pathogens and sediment as continuous variables.



K. Bruce Jones, Dan Heggem, Annie Neale, Maliha Nash, Megan Mehaffey, and Deb Chaloud, USEPA NERL, Landscape Division; James Wickham and Jonathan Smith, Landscape Characterization Branch

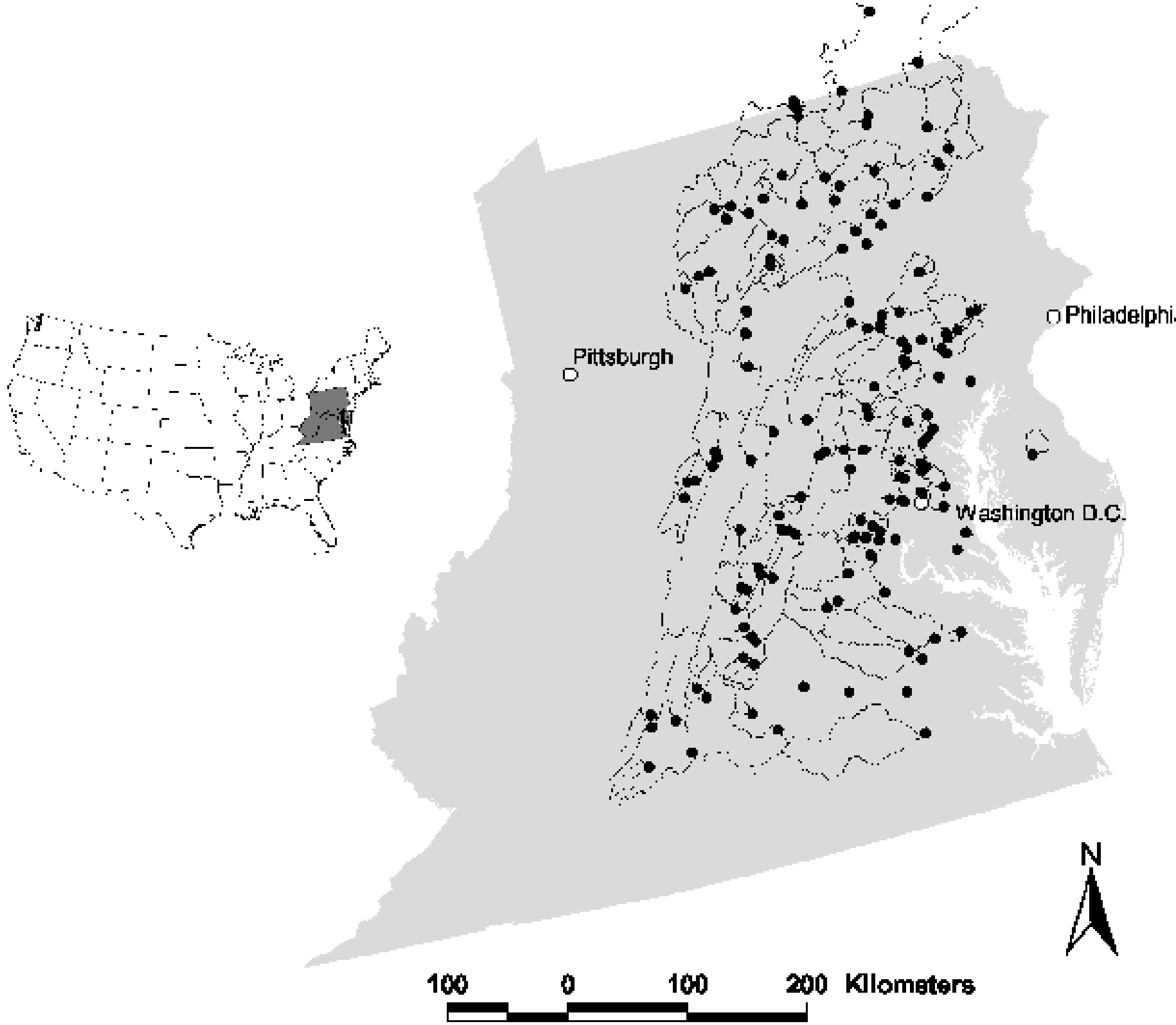
RESEARCH OBJECTIVES

- Develop landscape assessment approaches/simple models to assist in the identification and prioritization of watersheds/ water bodies vulnerable to non-point source pollution (regional scale down)
- Initial focus on nutrients, sediments, fecal coliforms, flow
- Develop new remote sensing approaches to improve assessments of watersheds/water bodies at risk to non-point source pollution
- Conduct regional and national assessments (historic/current/alternative futures) of watersheds/water bodies vulnerable to non-point source pollution
- Develop tools to aid environmental decision makers in evaluating vulnerability of watersheds/water bodies to non-point source pollution

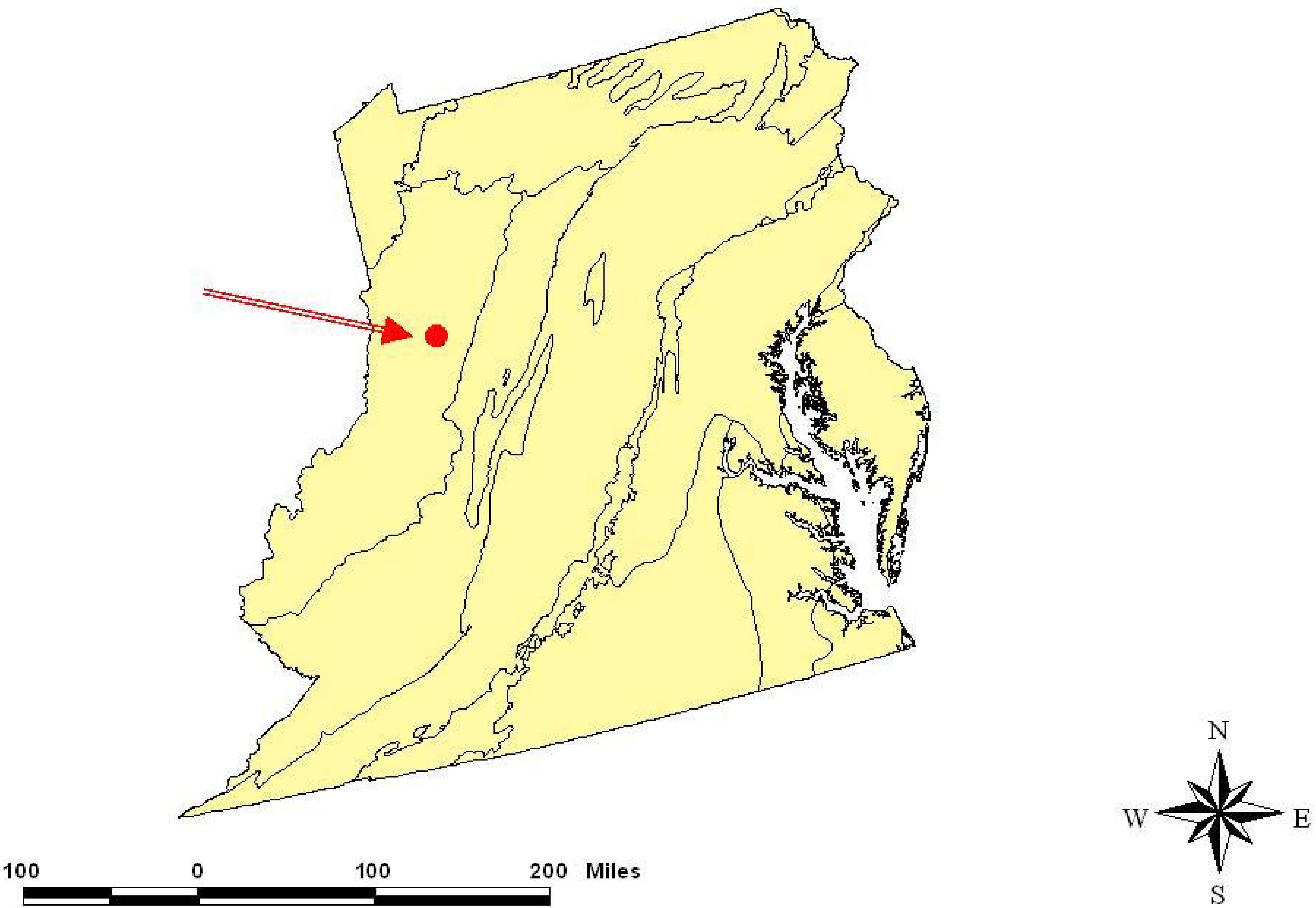
PRESENTATION HIGHLIGHTS

- Empirical studies linking landscape metrics to nutrients, sediment, and fecal coliforms.
- Simple statistical models to estimate nutrient export/nutrient and sediment loads
- Statistical models estimating the spatial distribution of potential exceedence of standards
- Evaluating the consequences of historical and future landscape change on nutrient loadings
- Examples of tools being developed

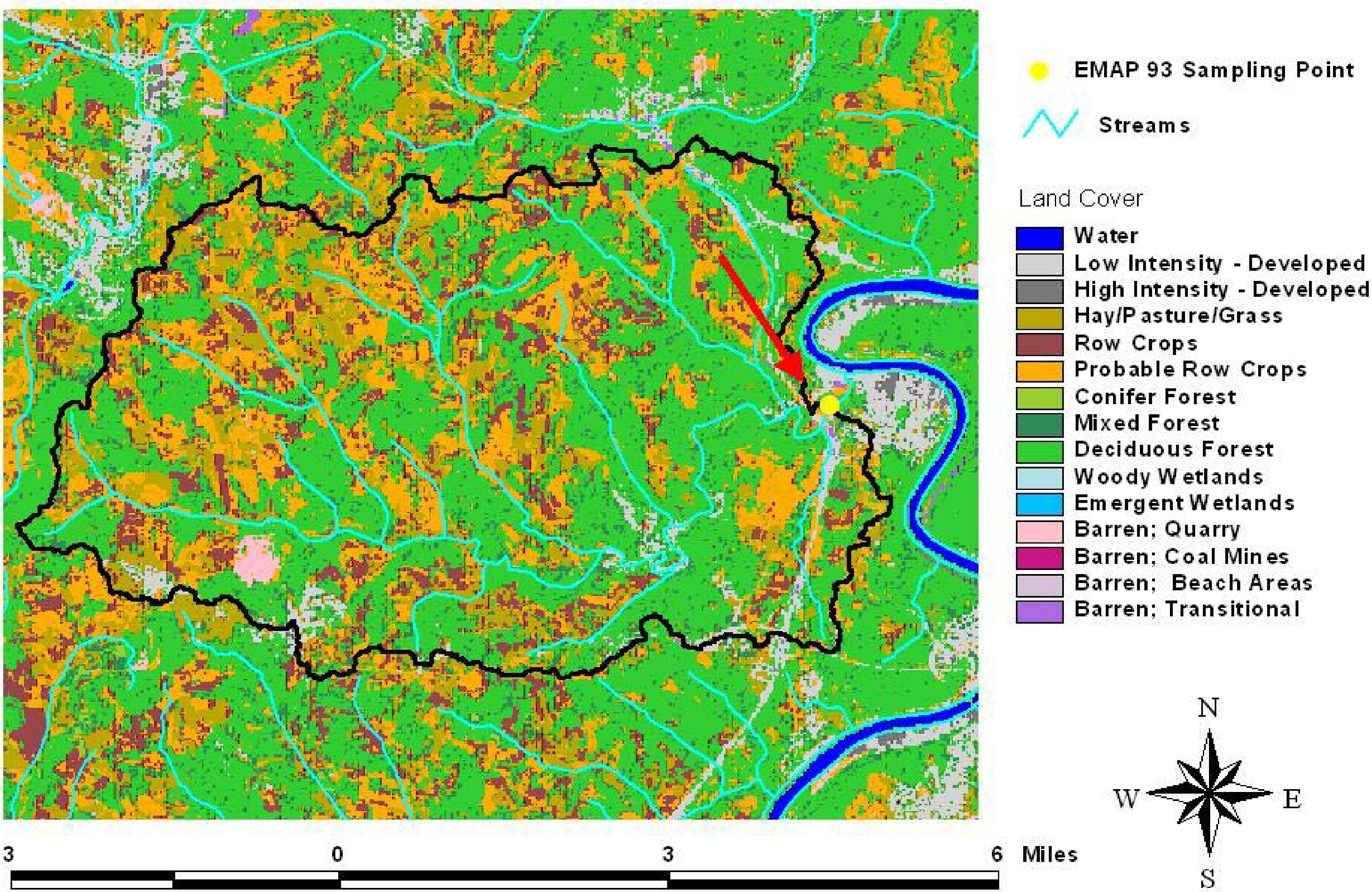
Quantify Relationships Between Landscape Conditions and Stream Conditions


Philadelphia
Pittsburgh
Washington D.C.
N
100 0 100 200 Kilometers

Location of Example Watershed

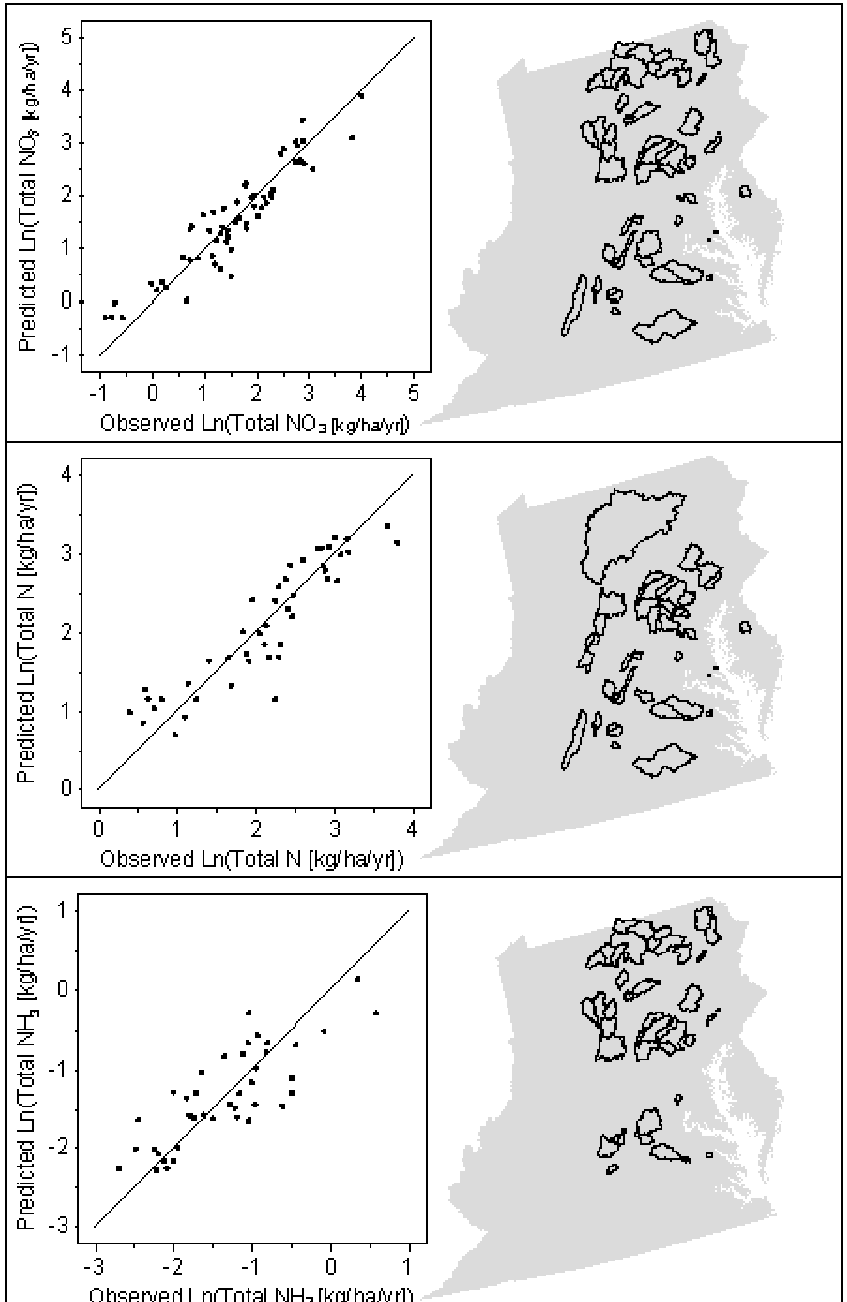


Example Watershed



Landscape Metrics

Mean Riparian agriculture
Riparian forest
Forest fragmentation
Road density
Forest land cover
Agricultural land cover
Agricultural land cover
  on steep slopes
Nitrate deposition
Potential soil loss
Roads near streams
Slope gradient
Slope gradient range
Slope gradient variance
Urban land cover
Wetland land cover
Barren land cover



$R^2 = .86$

% Ag

Nitrate Dep

Roads x Streams

% Urban

Riparian Ag

$R^2 = .83$

Riparian Forest

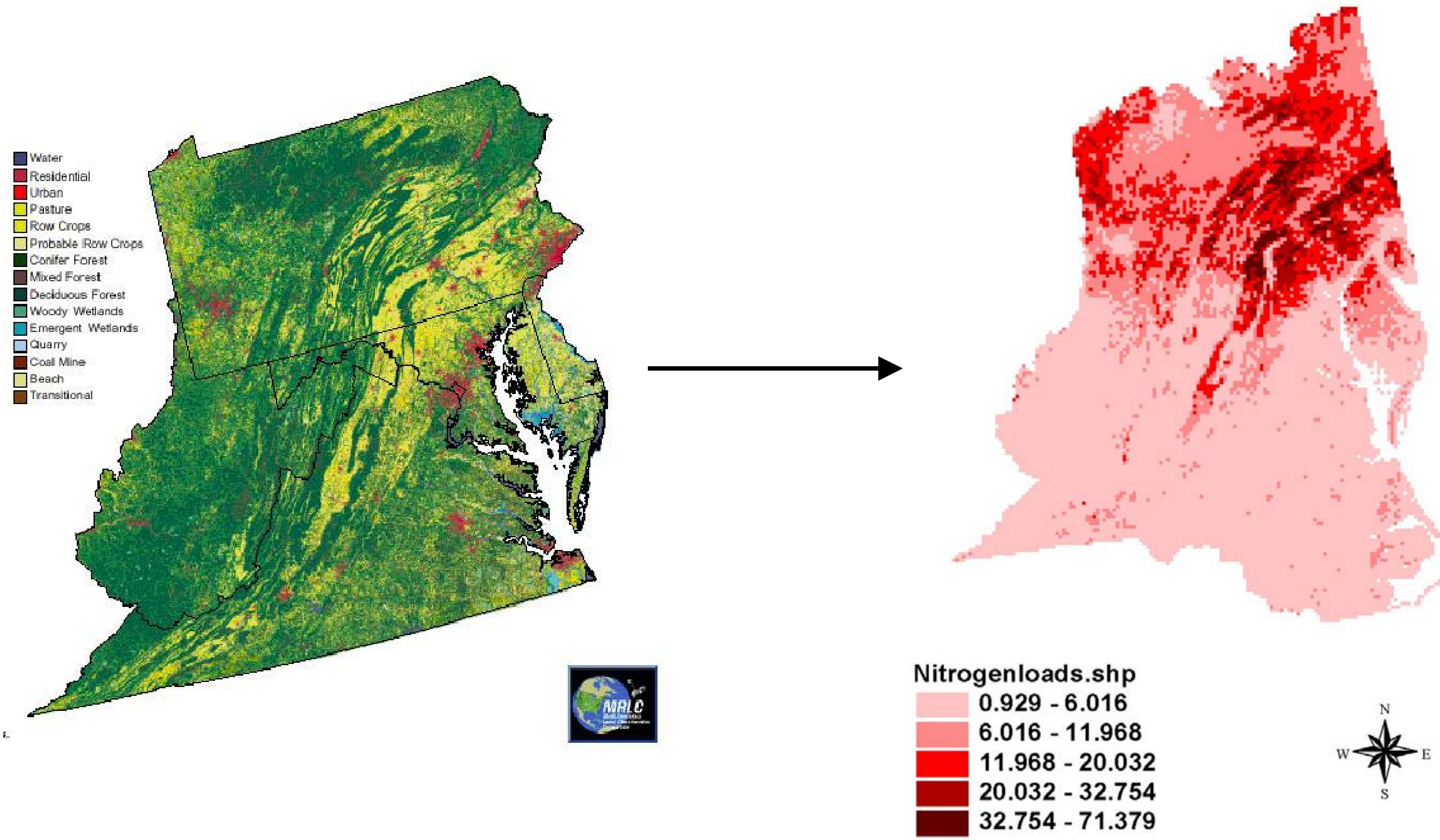
Nitrate Dep

$R^2 = .65$

Road Density

Riparian Forest

Applying the Total Nitrogen Model to a Surface



Utilizing Landscape Indicators to Model Potential Pathogen Impaired Waters

Jonathan H. Smith
James D. Wickham
Landscape Characterization Branch

K. Bruce Jones
Timothy G. Wade
Landscape Ecology Branch

U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory

Goal:

Predict the non-attainment of TMDL limits by analyzing land cover information for the state of South Carolina.

Data Sources:

- National Land Cover Data (NLCD)
  formerly known as the MRLC data set
- Watershed boundaries
- Water test results
- Stream network
- Digital Elevation Model (DEM)

Logistic Regression

- Analyzes the relationship between a binary response variable (exceeding standards, not exceeding standards) and a number of explanatory variables
- Calculates the probability of a specific response occurring
- Produces a number of diagnostic measures:
  - -2 Log Likelihood (-2LL)
  - Score
  - Concordance

Model Accuracy:

-2 Log L	86.11 ($p < 0.0001$)
Score	96.52 ($p < 0.0001$)

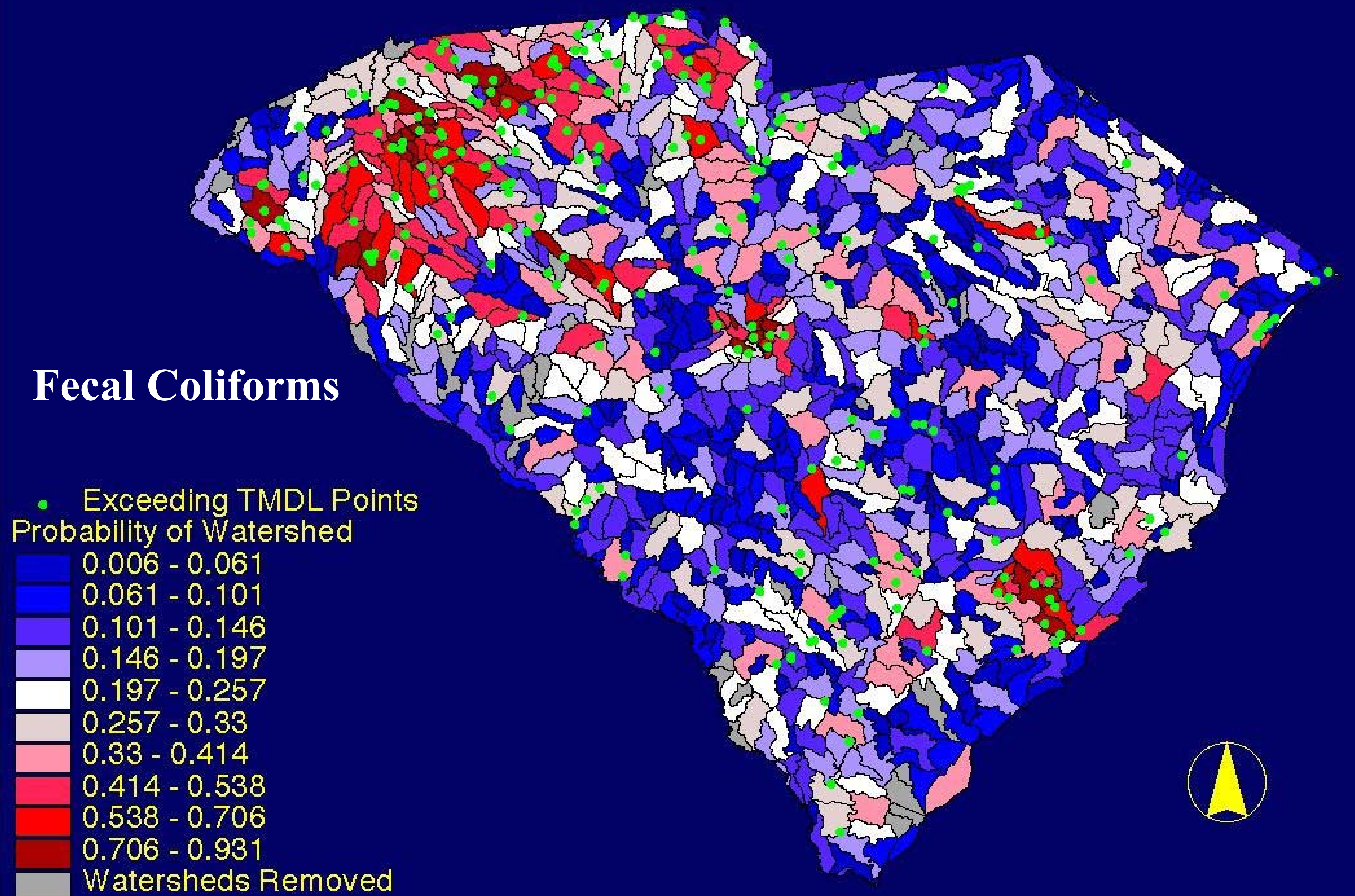
Concordant	71.8%
Discordant	27.5%
Tied	0.7%

(153,846 pairs)

Variables:

	Estimate	Standard Error	p - value
Intercept	-5.2	0.86	<0.0001
PCTURB	7.93	1.06	<0.0001
PCTAGSLP	5.85	1.21	<0.0001
NATSTCOV	3.65	0.96	<0.0001

Logistic Regression Results with Test Points



Modeling Nutrient Export Risk, Forecasting Changes in Risk Due to Urbanization and Examining the Effects of Risk Propagation and Scale

J. Wickham,[1] T. Wade,[1] K. B. Jones,[1] K. Riitters,[2] R.O'Neill,[3]
J.H. Smith,[1] K. Reckhow,[4] and E.R. Smith[1]

1 US EPA, Research Triangle Park, NC

2 US Forest Service, Research Triangle Park, NC

3 ORNL, Oak Ridge, TN

4 Duke University, and NC Water Resources Research Institute

Nitrogen Export
kg/ha/yr

Forest	Urban	Agriculture
0.1	5.0	3.2
0.1	5.0	4.8
0.2	5.0	5.0
0.7	5.1	5.0
2.2	5.4	5.8
2.5	6.7	9.1
2.5	7.9	9.6
2.6	9.6	9.8
3.0	9.6	11.9
3.7	12.0	14.0
4.4	16.3	20.0
7.6	18.0	20.6
12.2	28.0	22.3
		23.5
		33.3

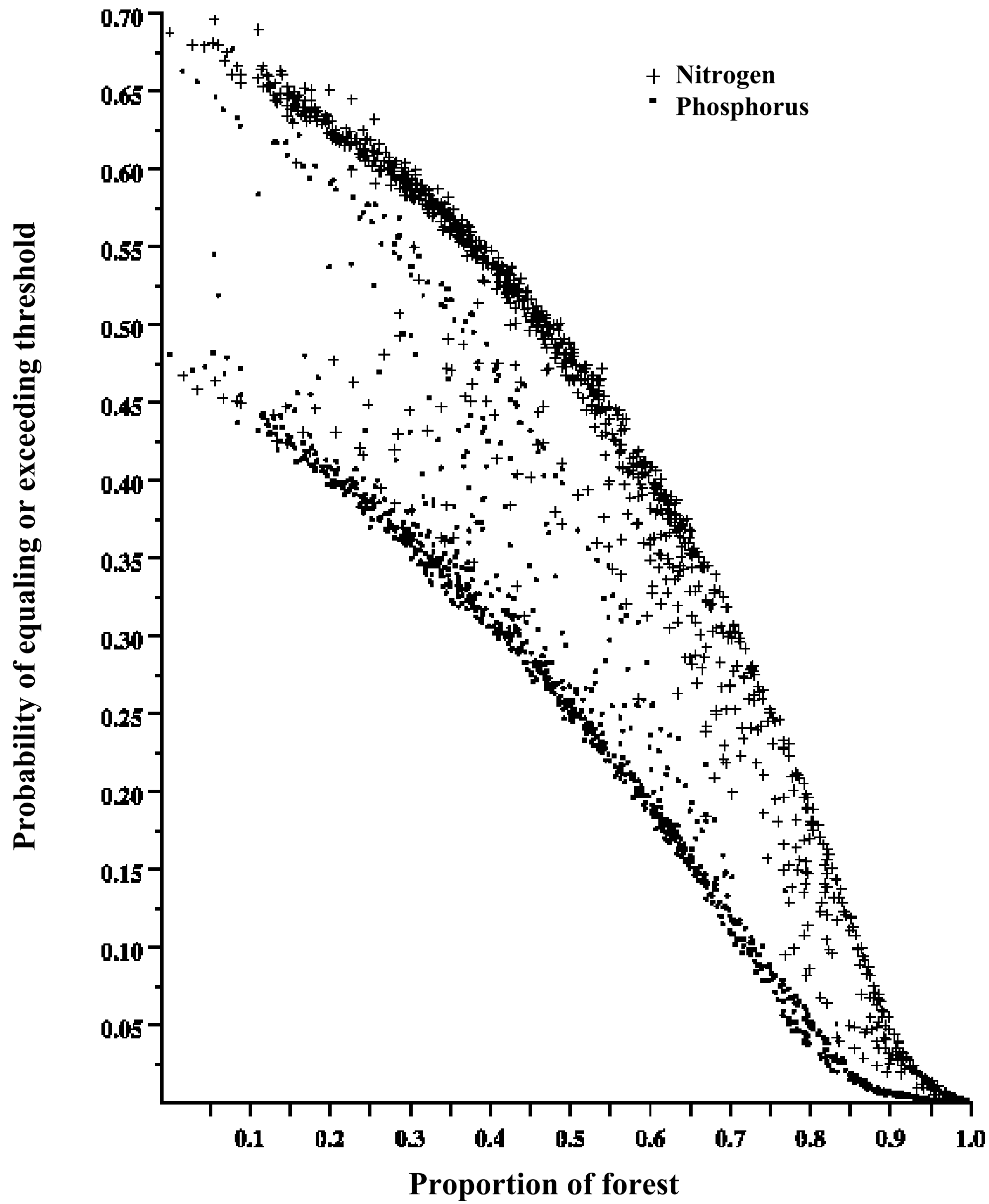
Source: Frink (*JEQ*, 1991, 20:717)

Land-Cover	WS (ha)	N/P	# of Obs.	Min	Q_{25}	Q_{50}	Q_{75}	Max
Agriculture	40-8000	N	30	2.1	6.6	11.1	20.3	53.2
Urban	4-4800	N	19	1.5	4.0	6.5	12.8	38.5
Forest	7-47000	N	21	1.4	1.9	2.5	3.3	7.3
Agriculture	40-8000	P	27	0.08	0.49	0.91	1.34	5.40
Urban	4-4800	P	24	0.19	0.69	1.10	3.39	6.23
Forest	7-47000	P	62	0.01	0.04	0.08	0.22	0.83

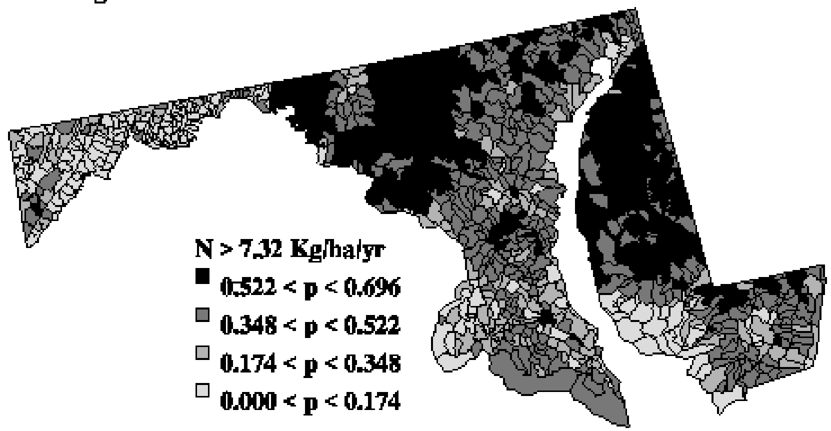
$$N, P = \sum_{i}^{n} (C_i * \mathrm{A}_i)$$

	N	P
Threshold	7.0	0.8

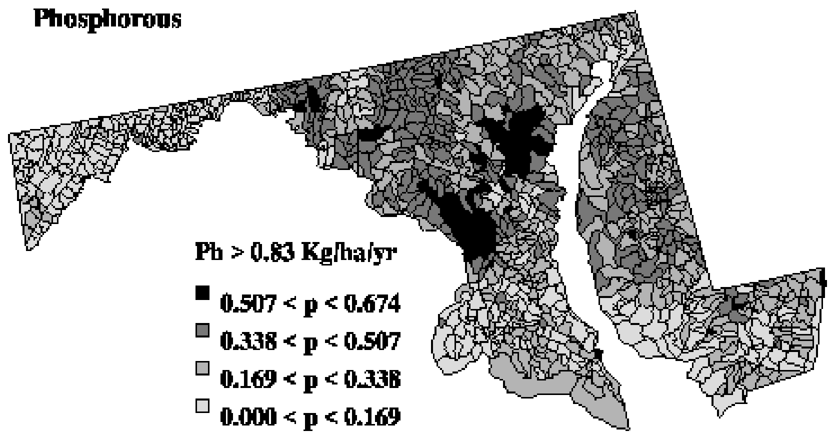
Risk: # of iterations / 10000 >= 7.0 or 0.8


Nitrogen
Phosphorus
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Probability of equaling or exceeding threshold
Proportion of forest

Nitrogen

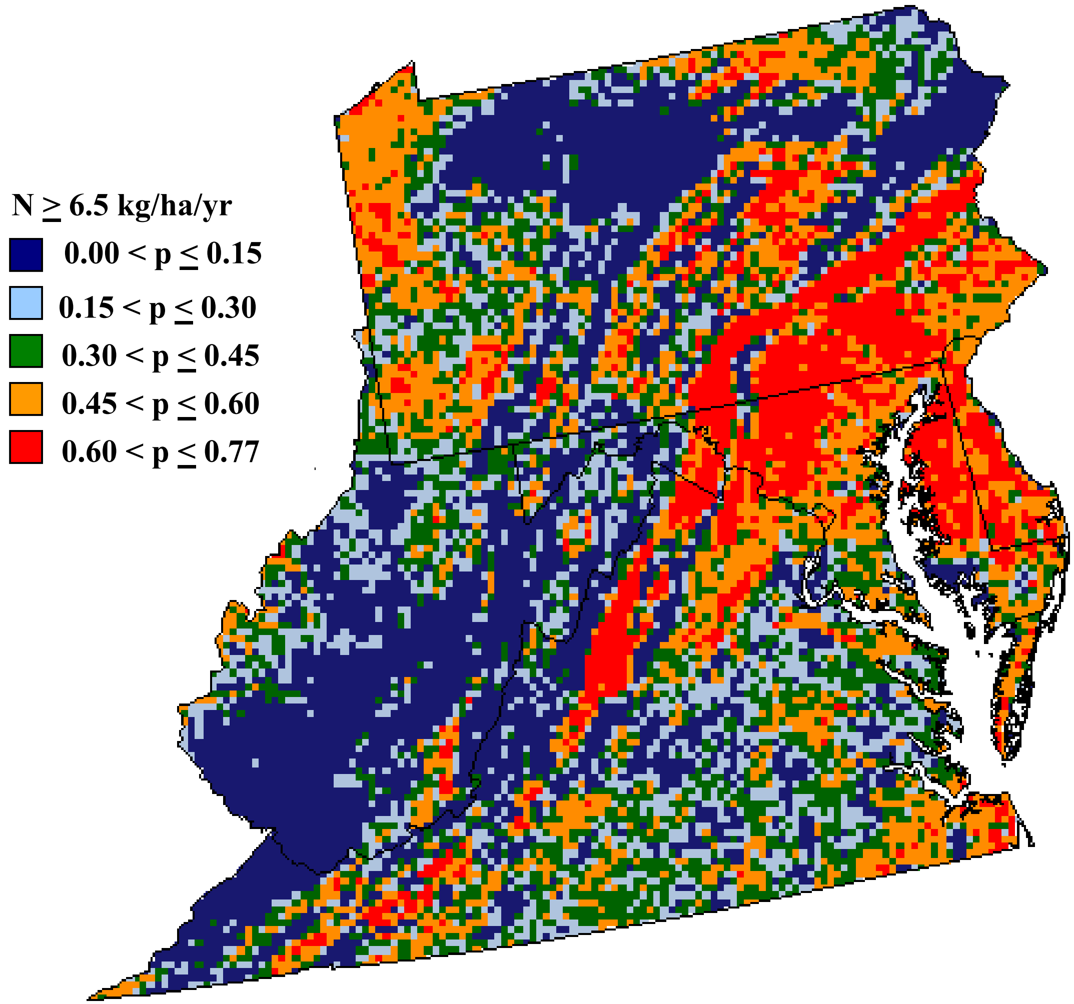


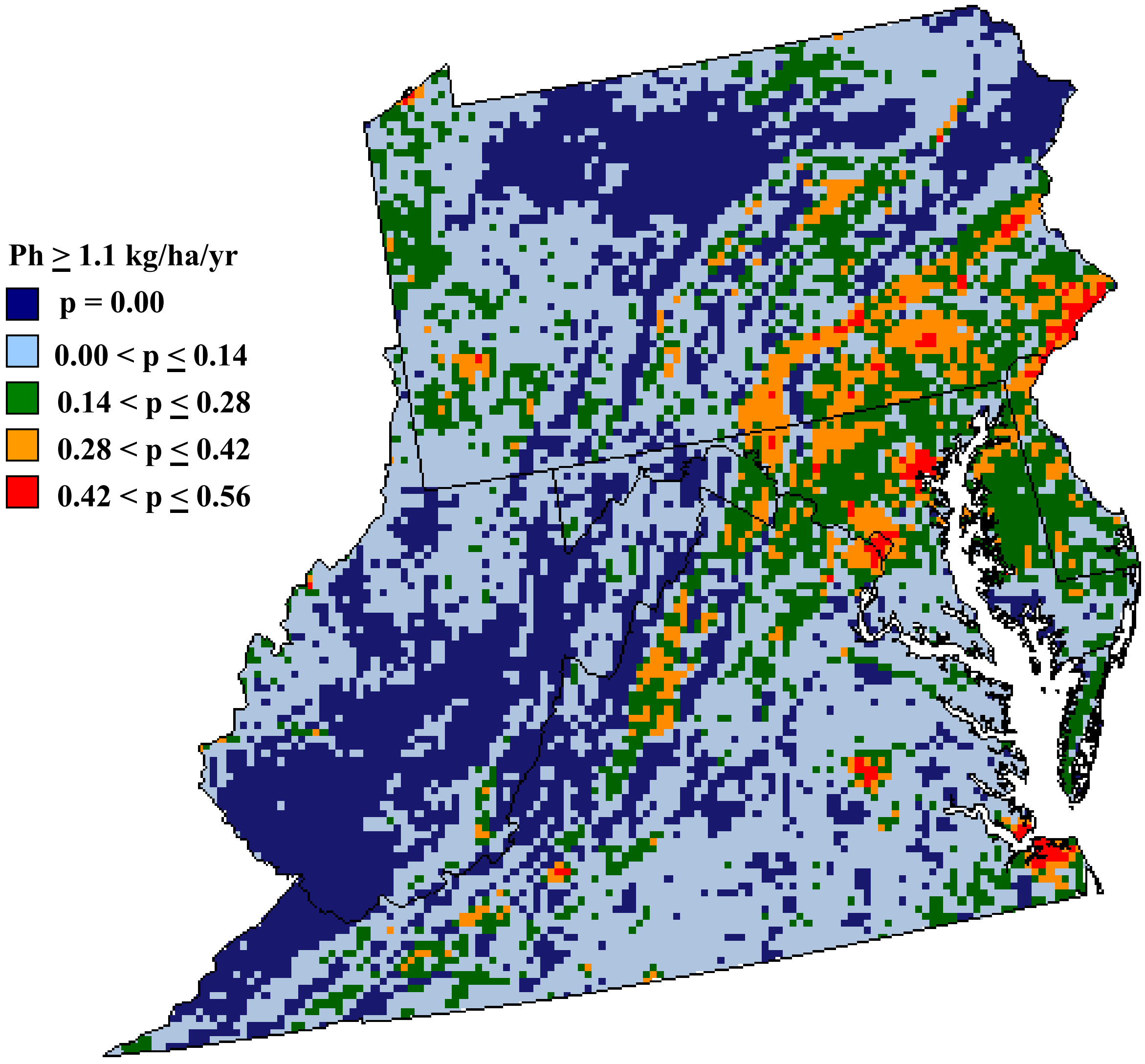
Phosphorous



Forecasting part

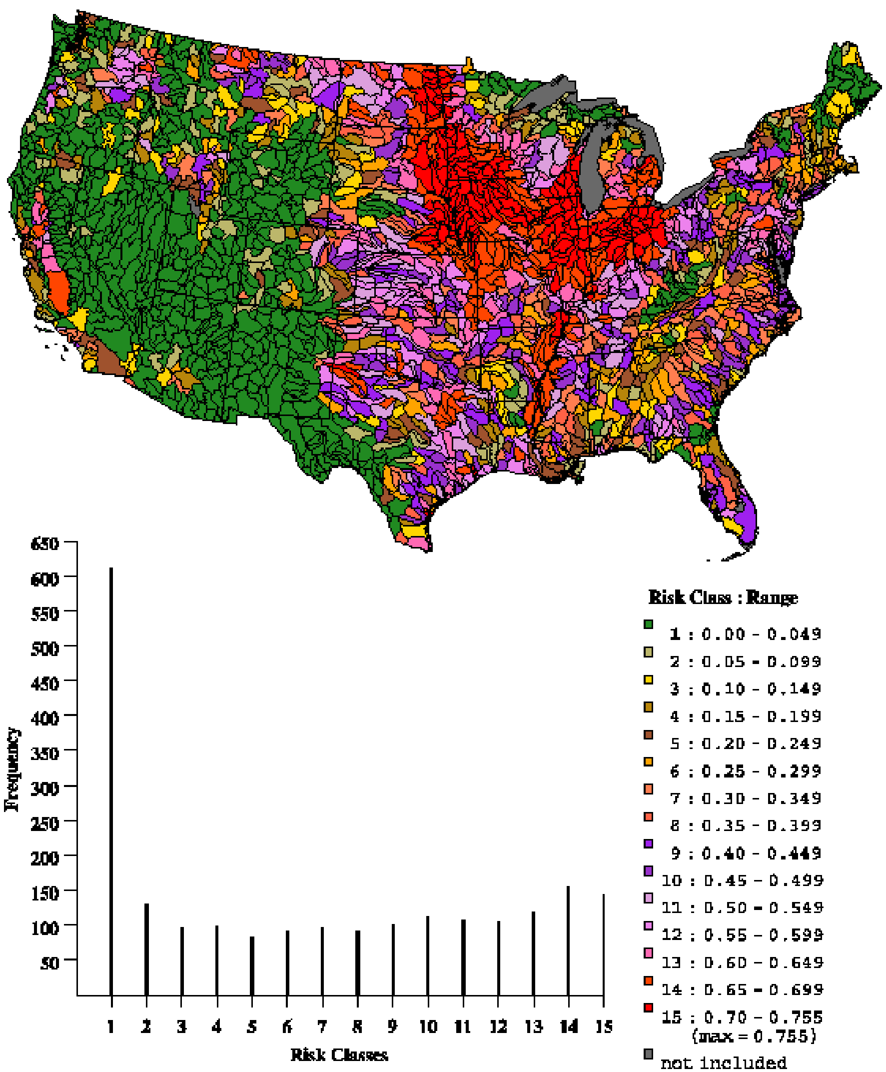
- urban, vulnerability = two spatial patterns



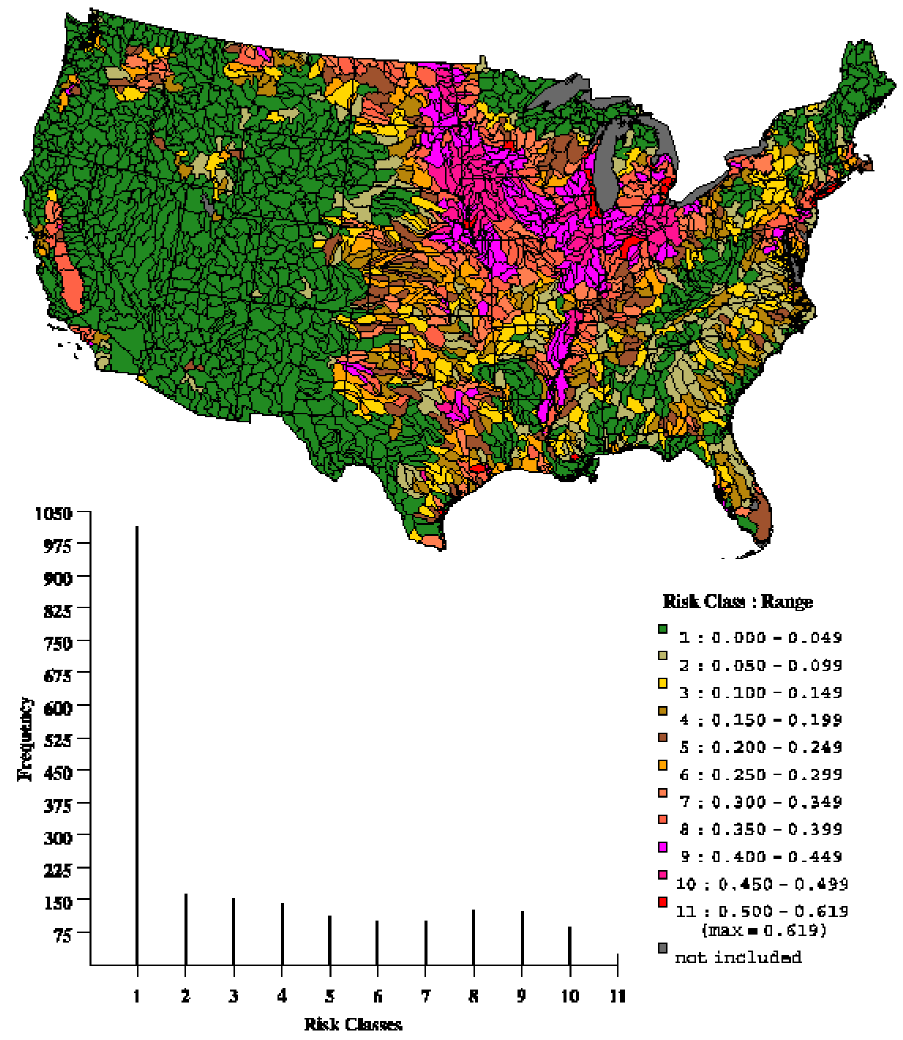

Ph ≥ 1.1 kg/ha/yr
p = 0.00
0.00 < p ≤ 0.14
0.14 < p ≤ 0.28
0.28 < p ≤ 0.42
0.42 < p ≤ 0.56

National Assessment of Nitrogen and Phosphorus Export Risk

Risk of Nitrogen Export

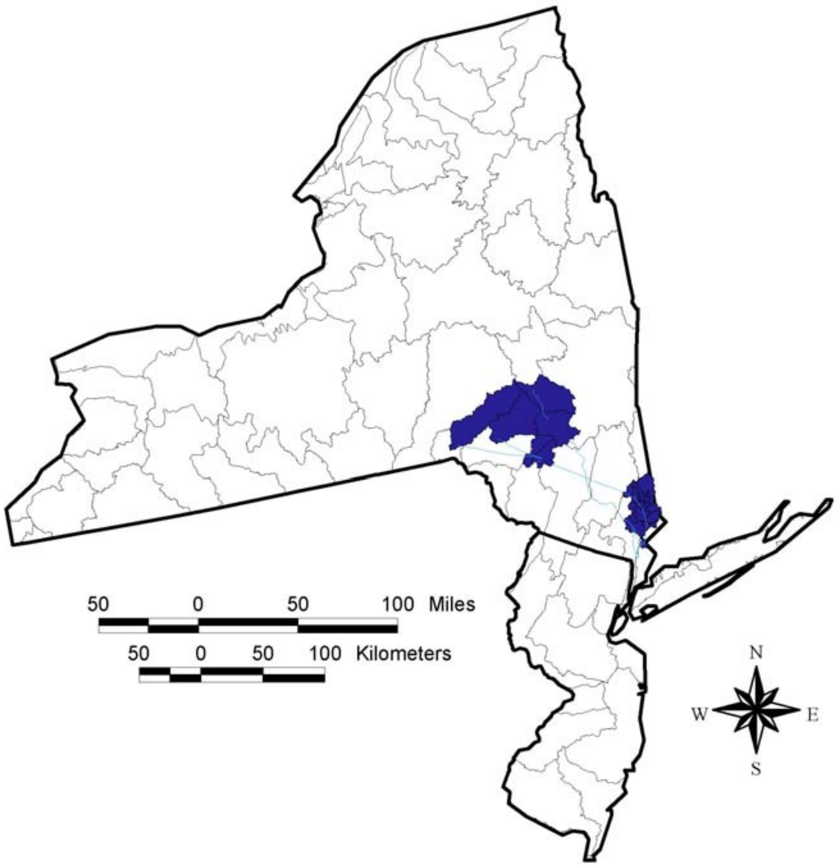


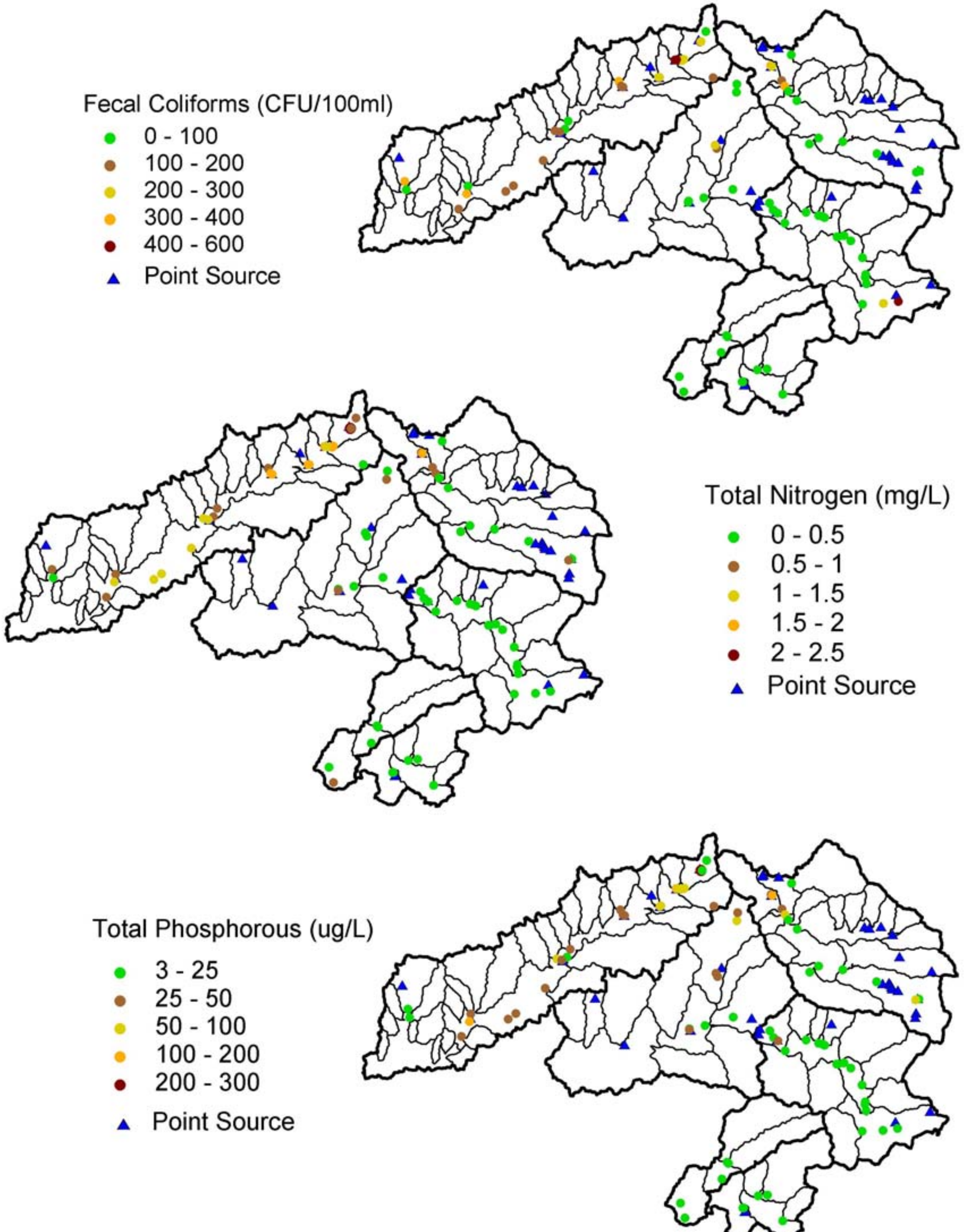
Risk of Phosphorus Export



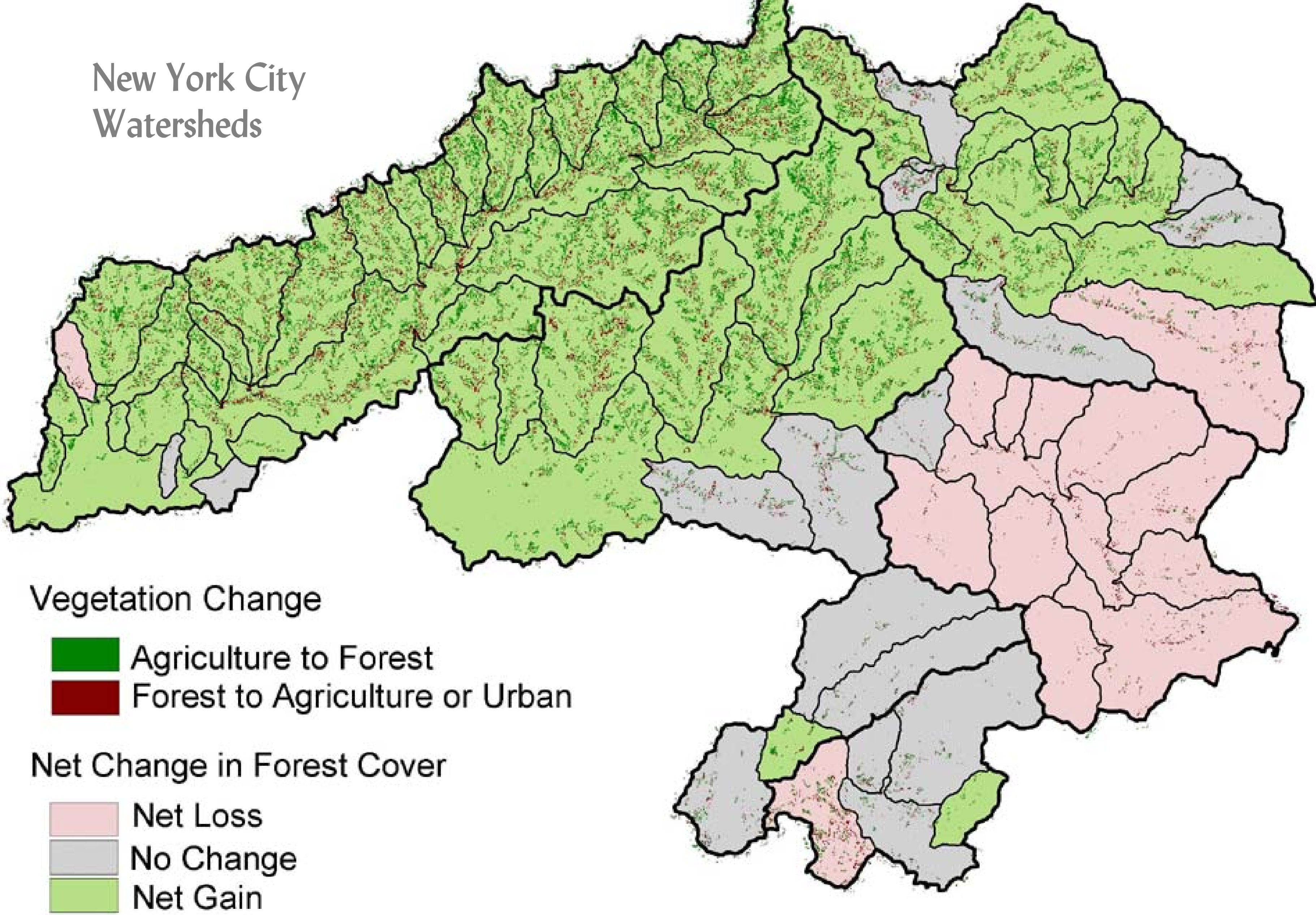
Historical Change and Consequences

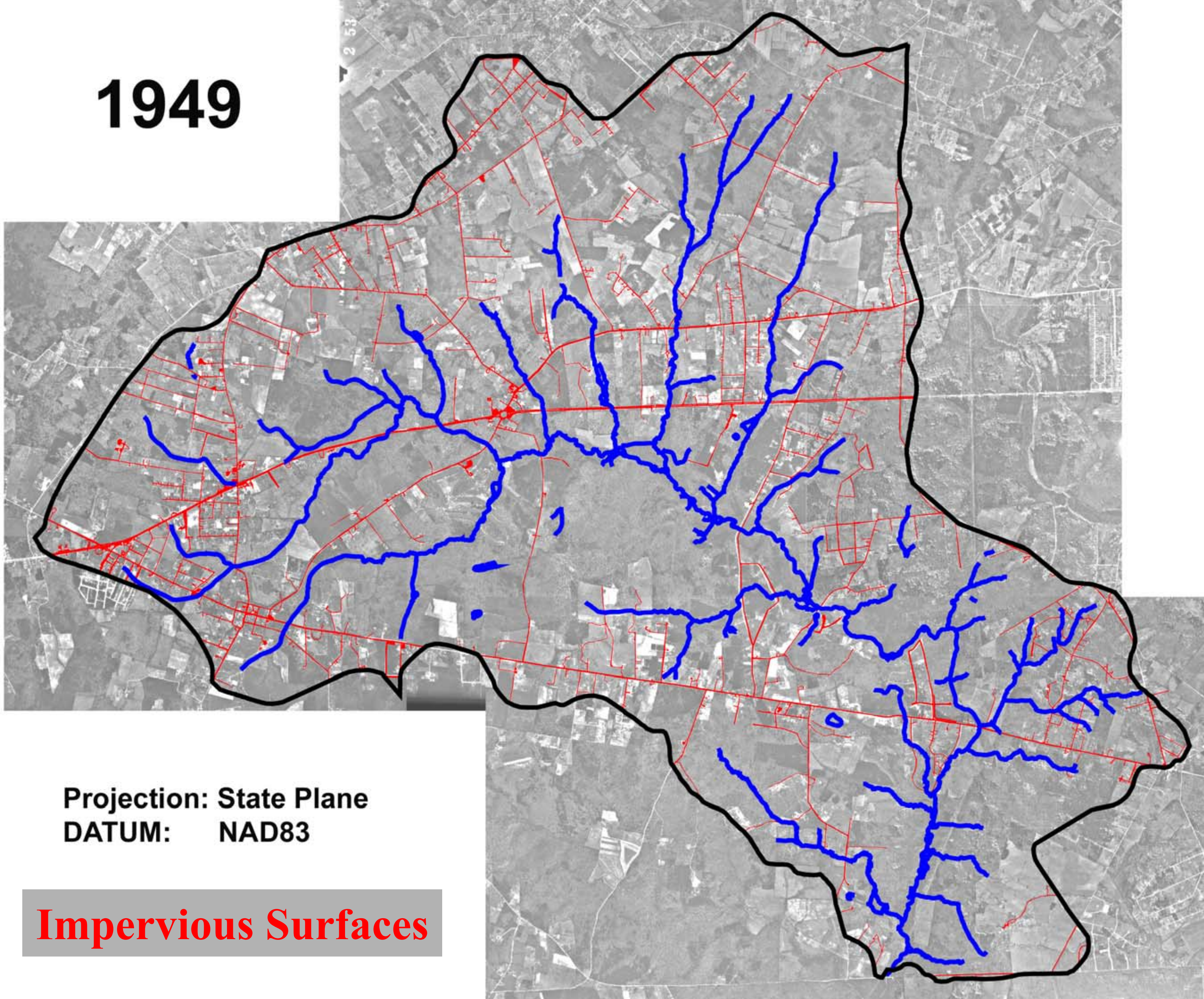
New York City Watershed Change Study



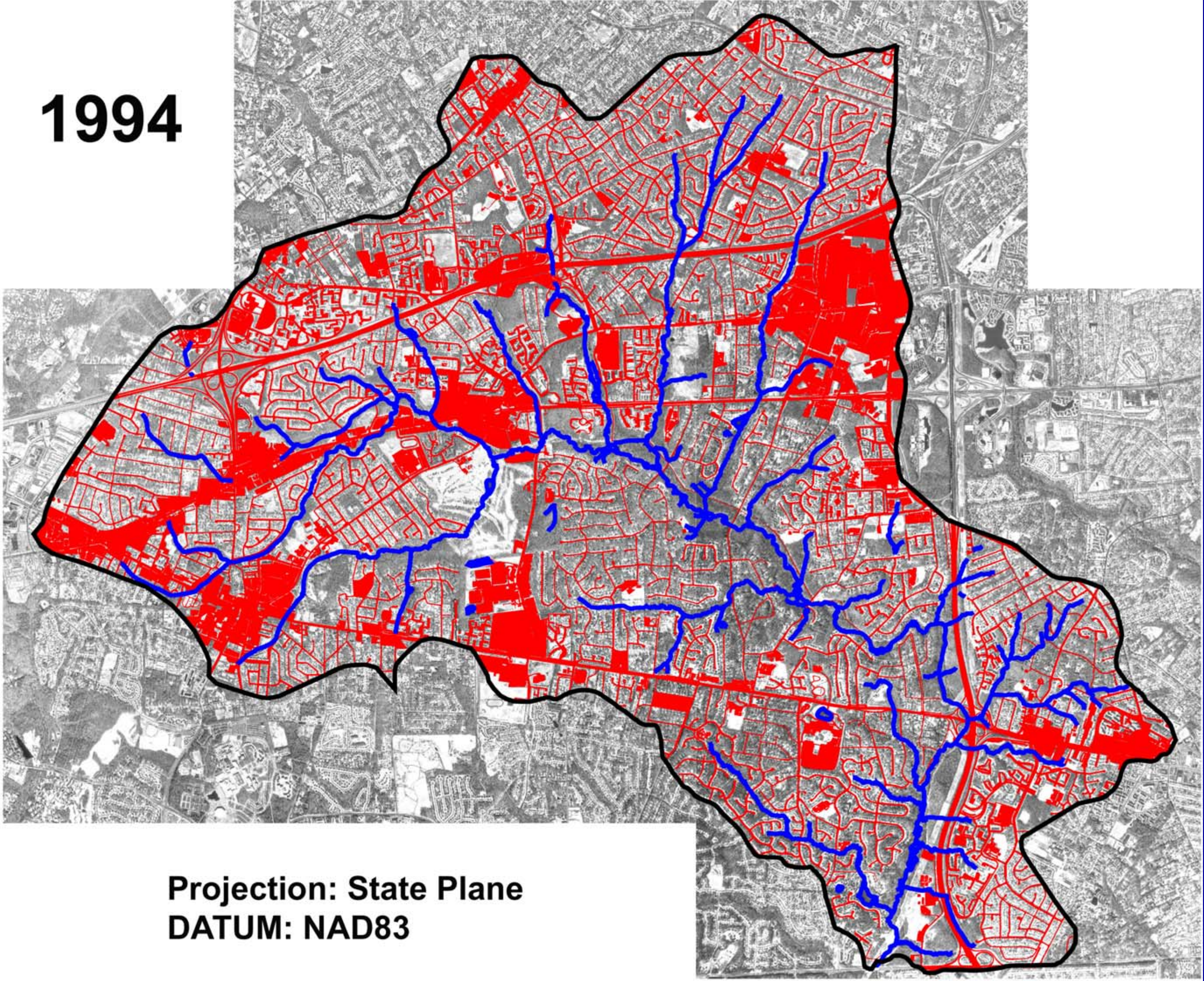


Fecal Coliforms (CFU/100ml)
0 - 100
100 - 200
200 - 300
300 - 400
400 - 600
Point Source
Total Nitrogen (mg/L)
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 2.5
Point Source
Total Phosphorous (ug/L)
3 - 25
25 - 50
50 - 100
100 - 200
200 - 300
Point Source

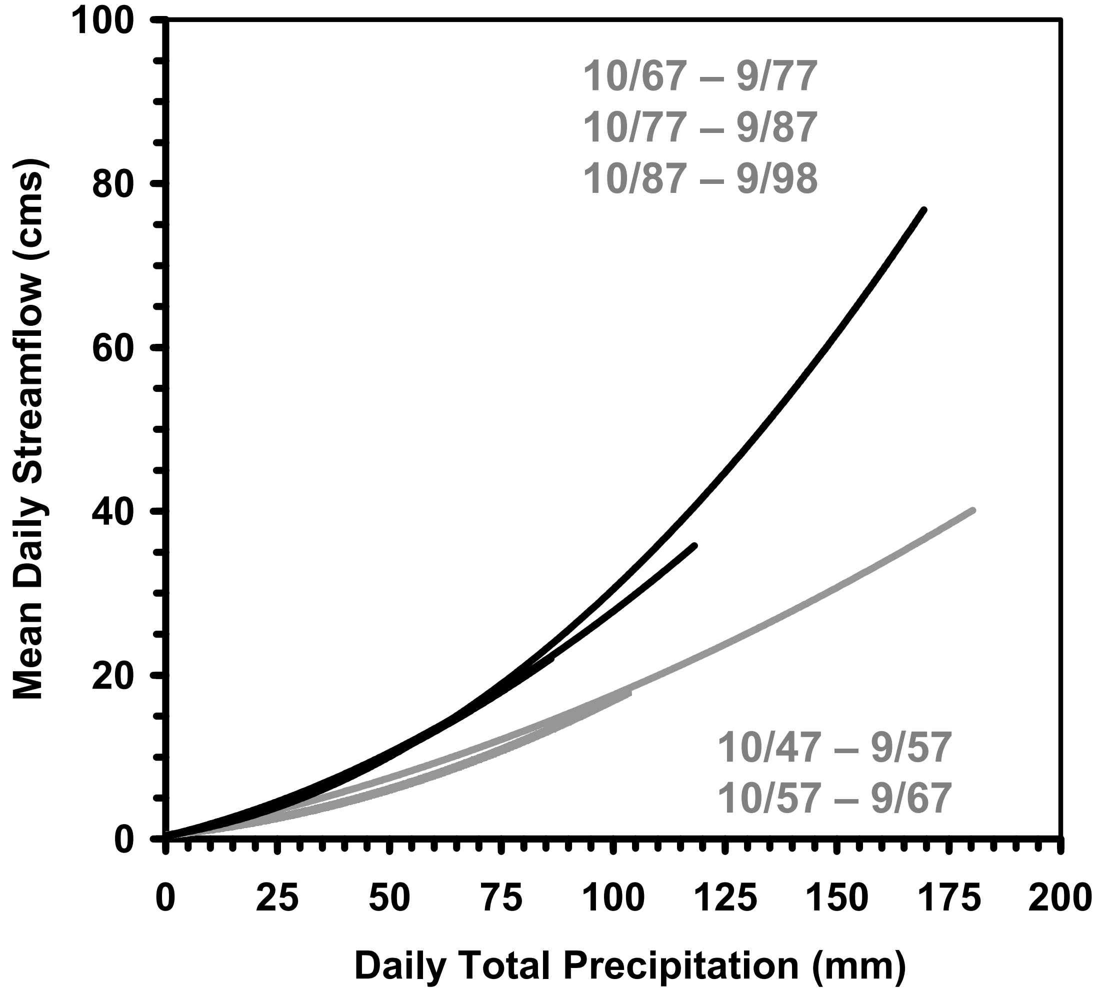

New York City
Watersheds
Vegetation Change
Agriculture to Forest
Forest to Agriculture or Urban
Net Change in Forest Cover
Net Loss
No Change
Net Gain


1949
Projection: State Plane
DATUM: NAD83
Impervious Surfaces

1994



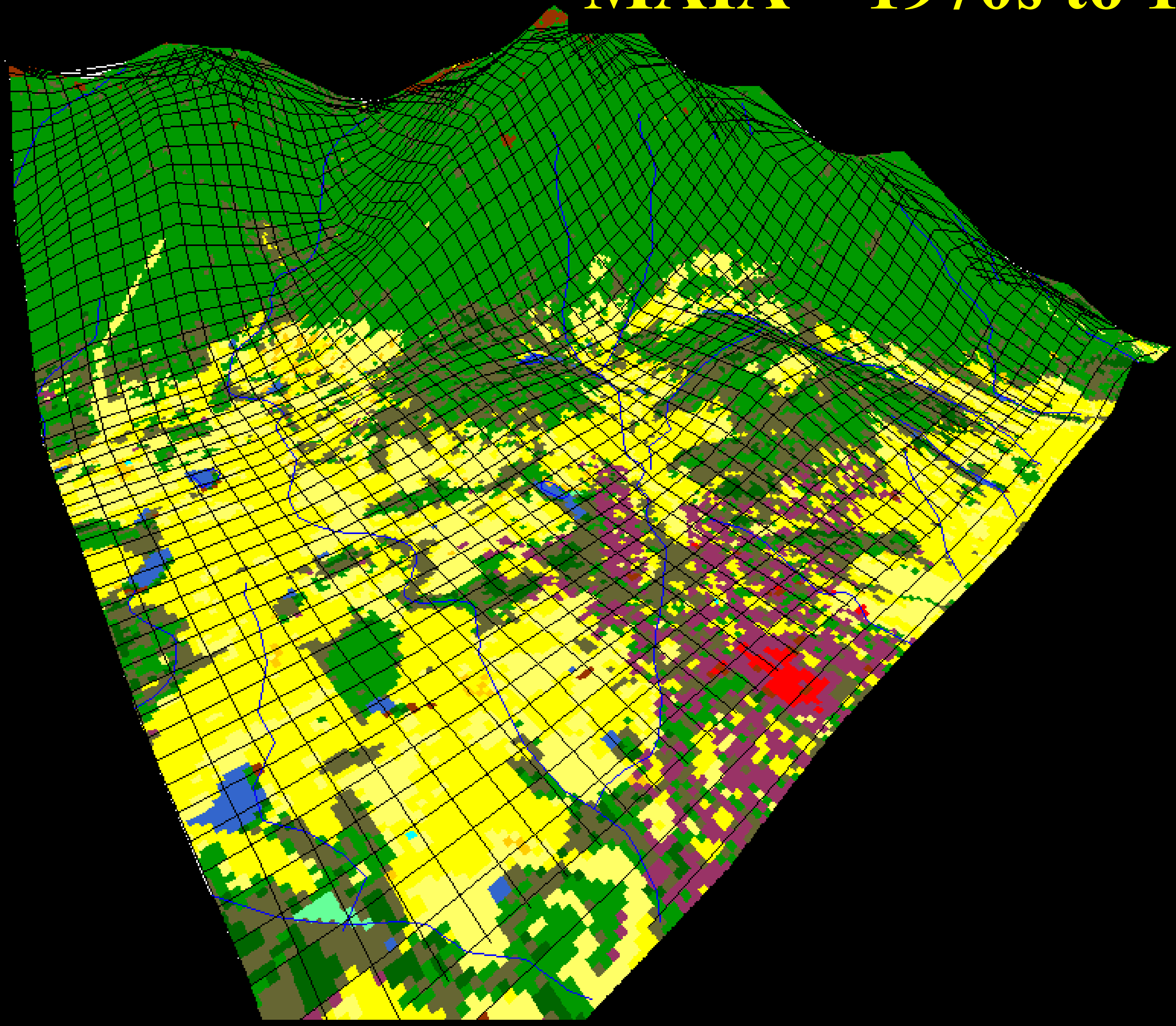
Projection: State Plane
DATUM: NAD83

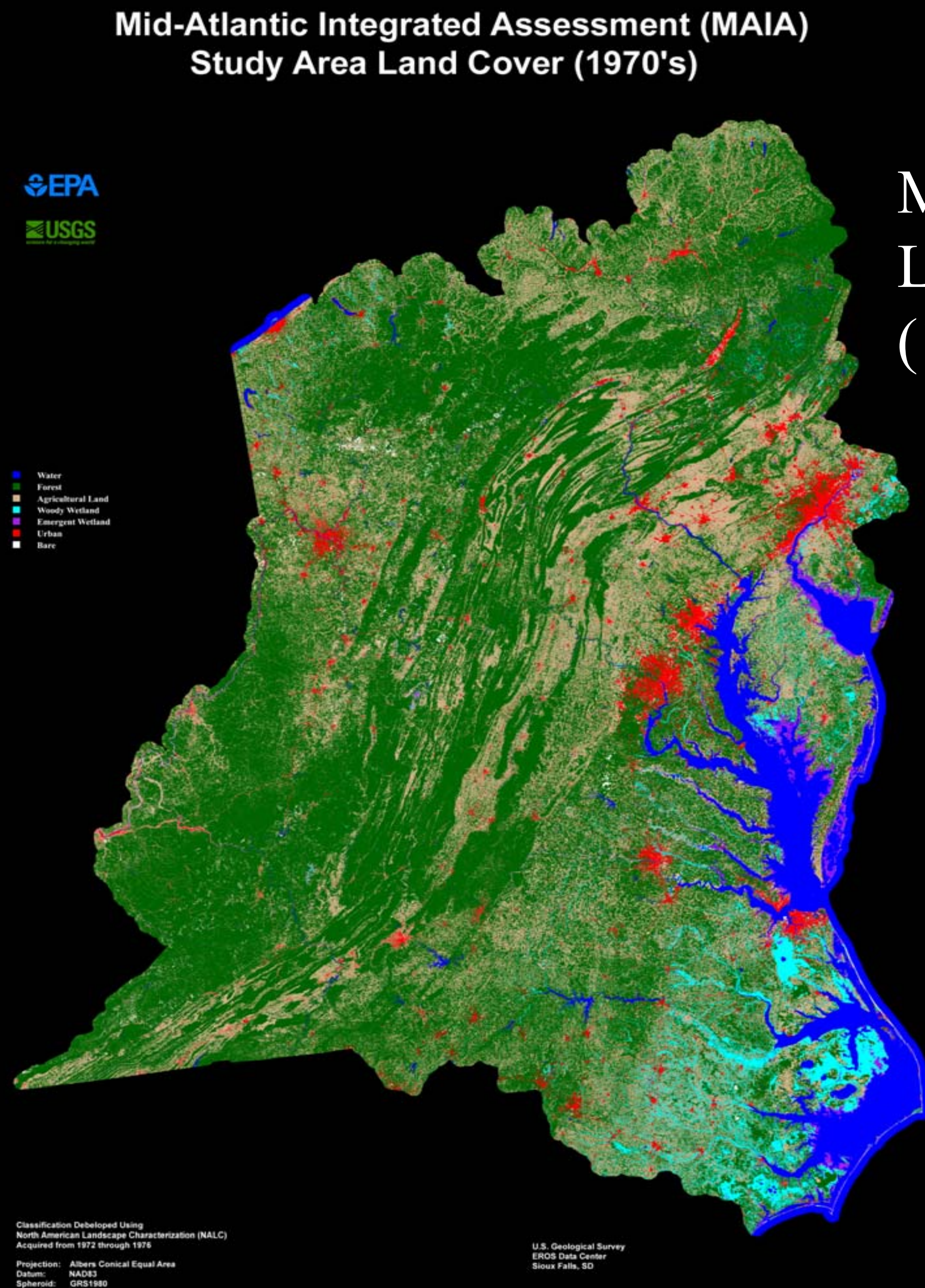


1947 - 1998 Streamflow vs. Precipitation

From: Jennings and Jarnagin 2002. Landscape Ecol. In press.

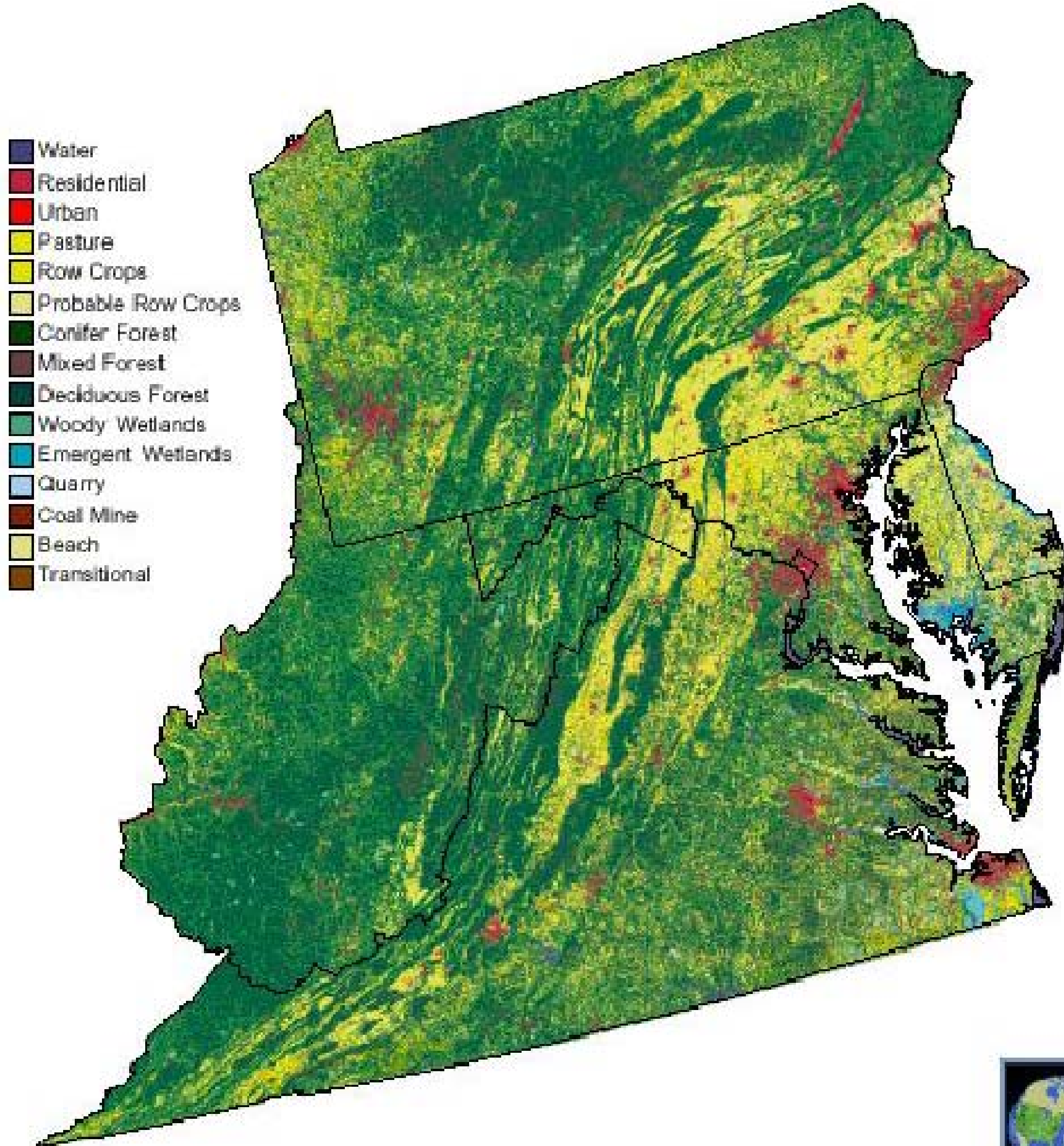
MAIA – 1970s to 1990s



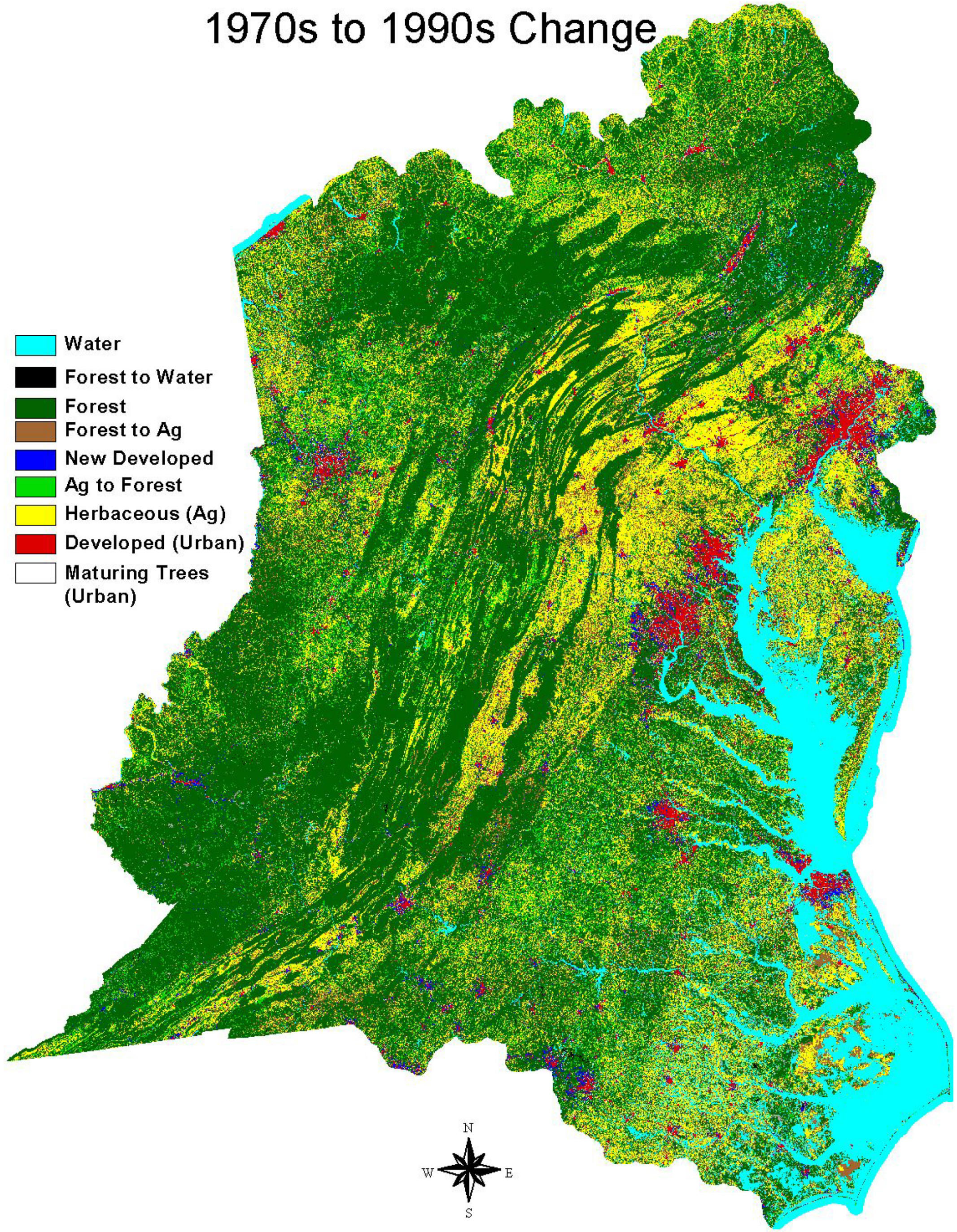


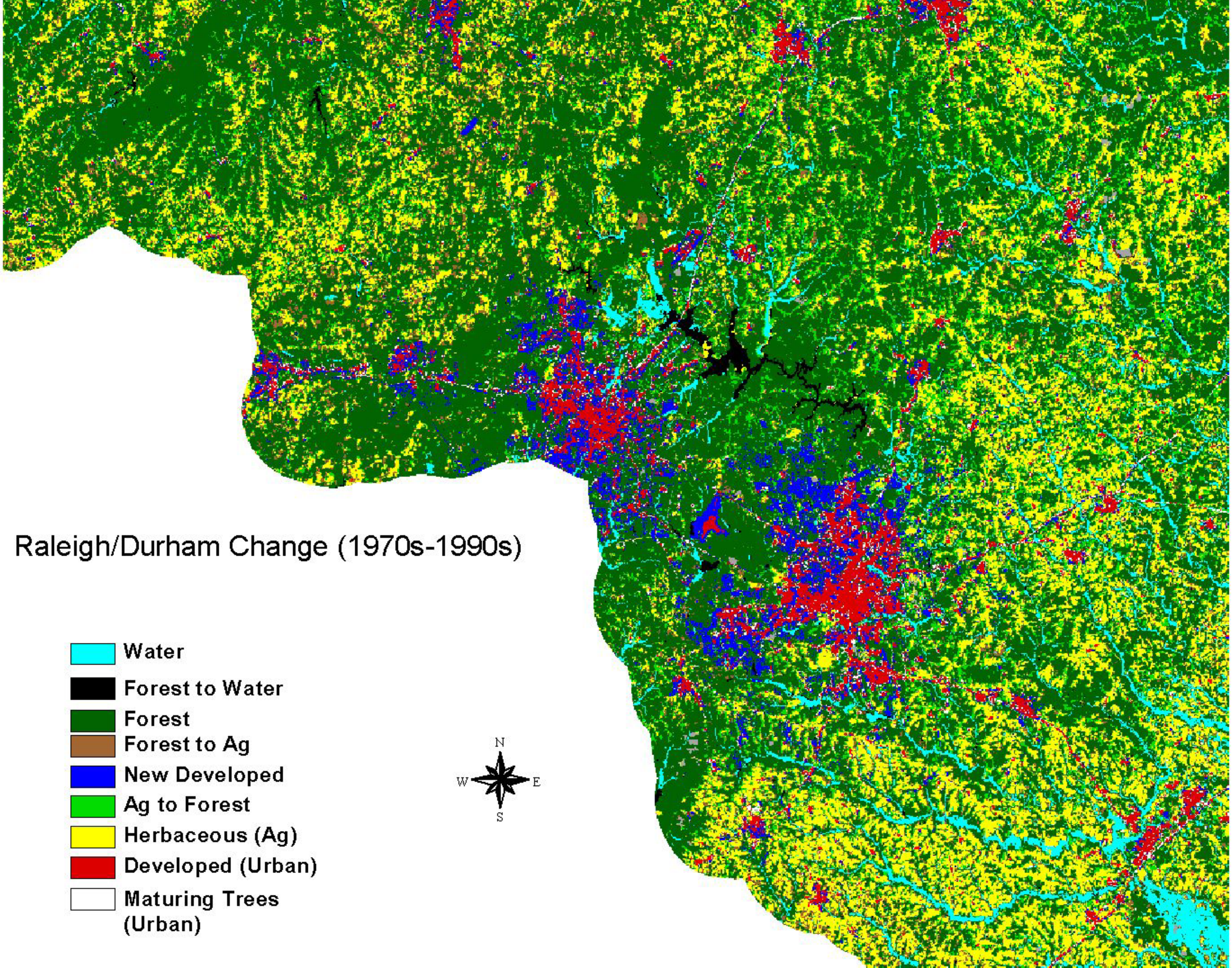
Mid-Atlantic Landscape Change (1970s-1990s)

NLCD 1990s Land Cover Data



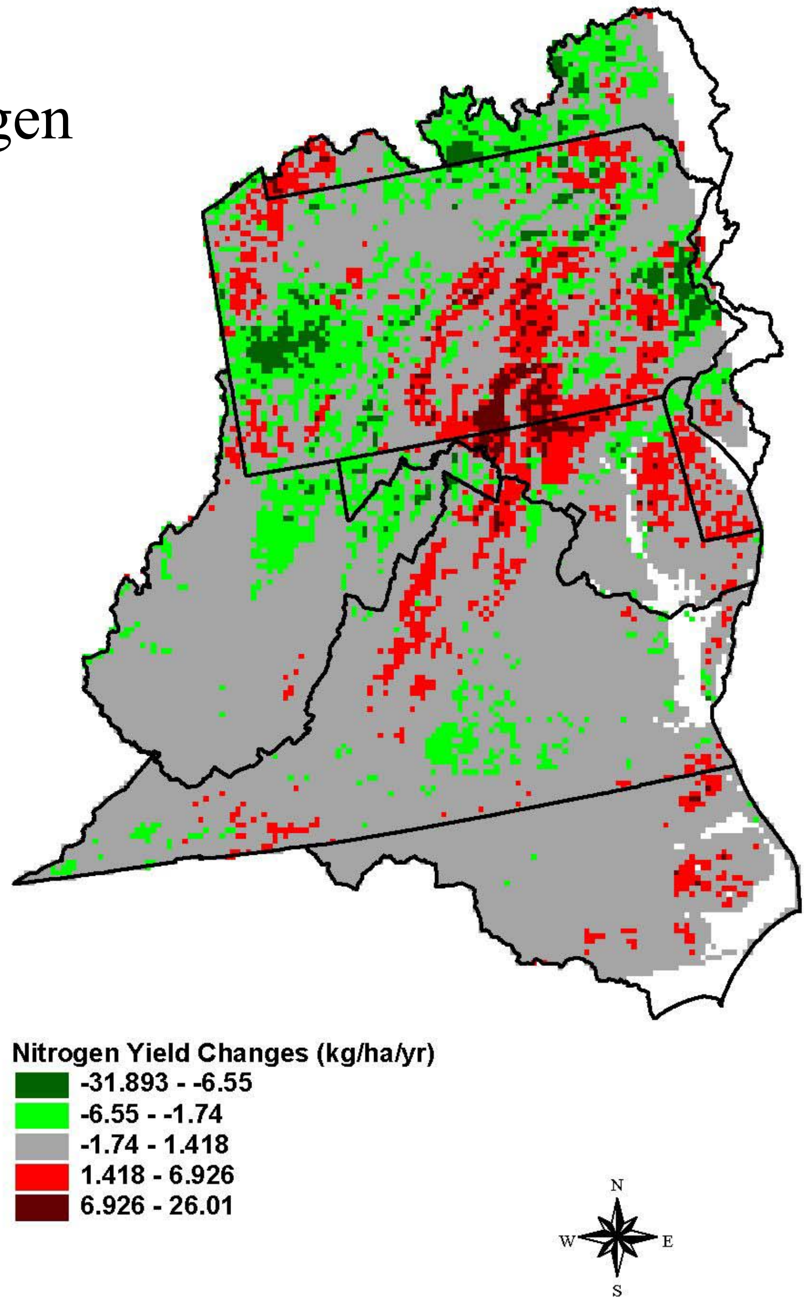
1970s to 1990s Change



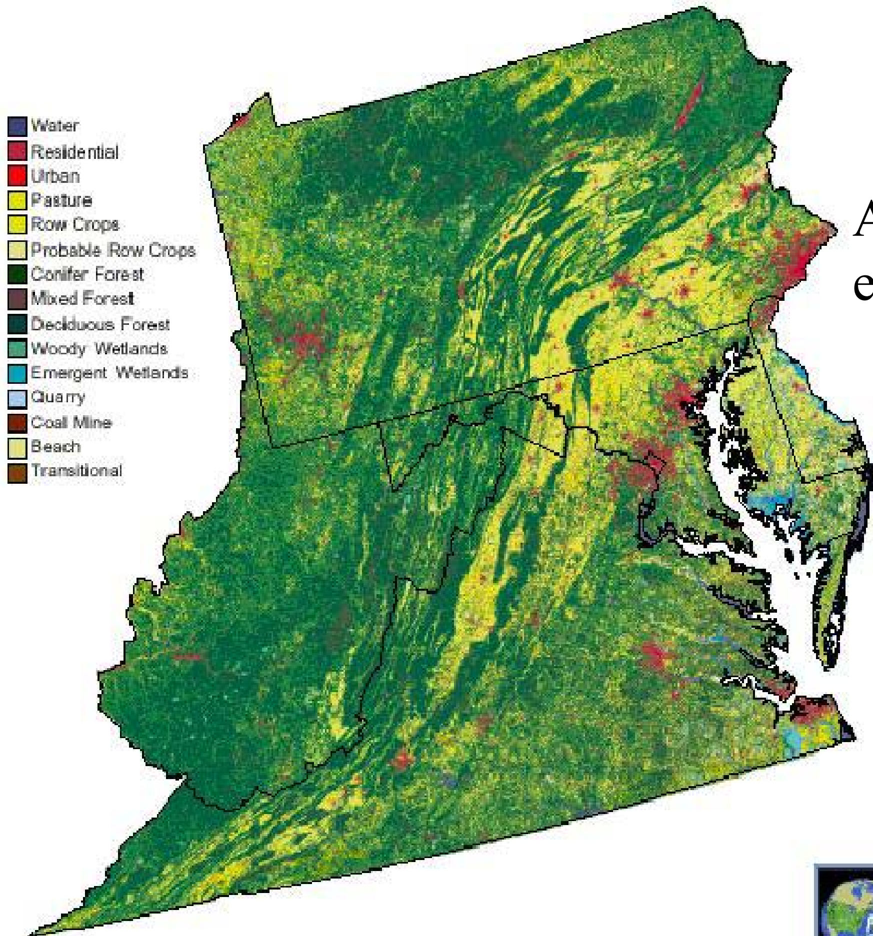


Raleigh/Durham Change (1970s-1990s)

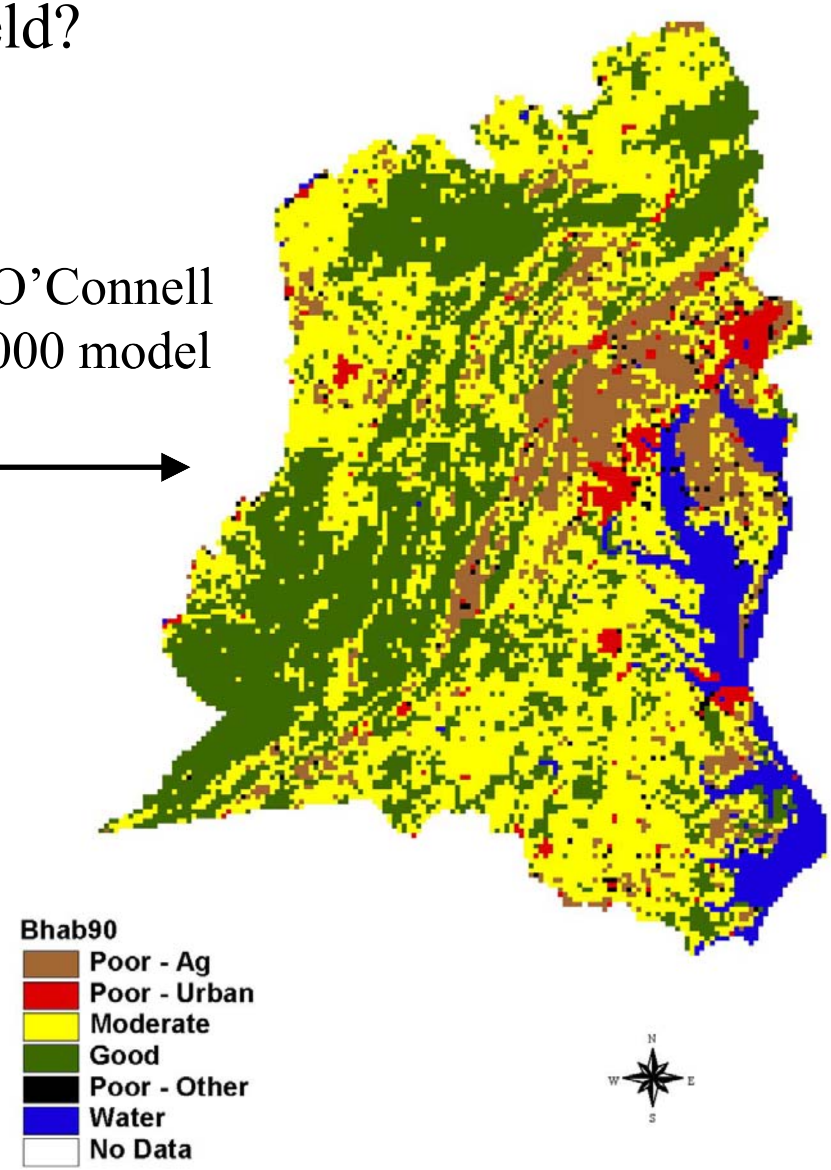
Changes in Nitrogen Yield - Model Implemented On 25 km^2 Grid Cells



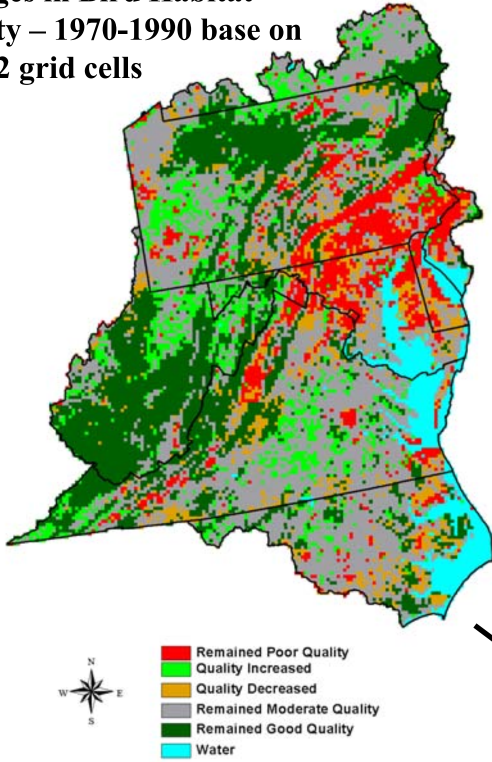
How similar is the pattern of change in bird habitat quality to changes in nitrogen yield?



Apply O'Connell et al. 2000 model



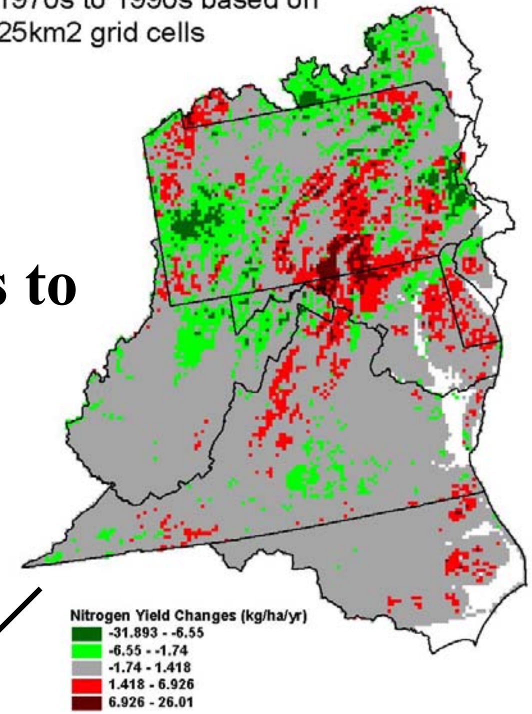
Changes in Bird Habitat Quality – 1970-1990 base on 25km2 grid cells

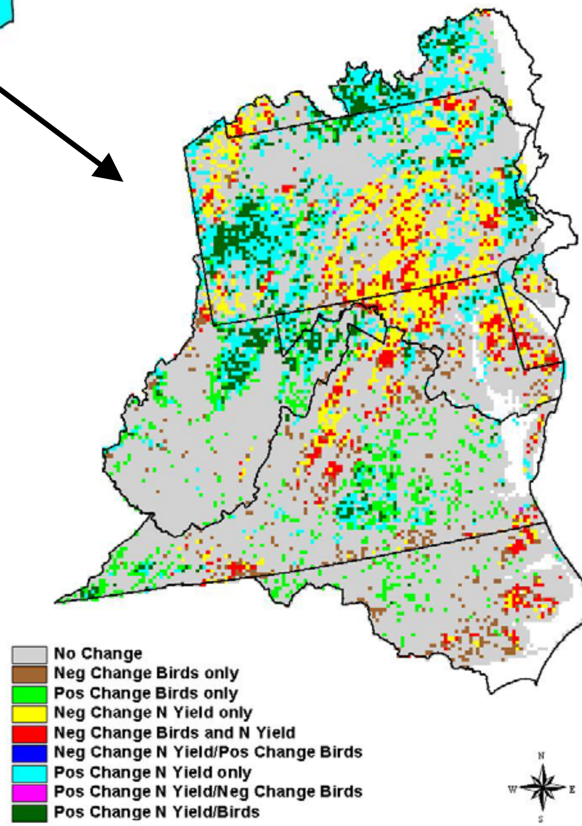


Bird Habitat Quality

Nitrogen Loadings to Streams

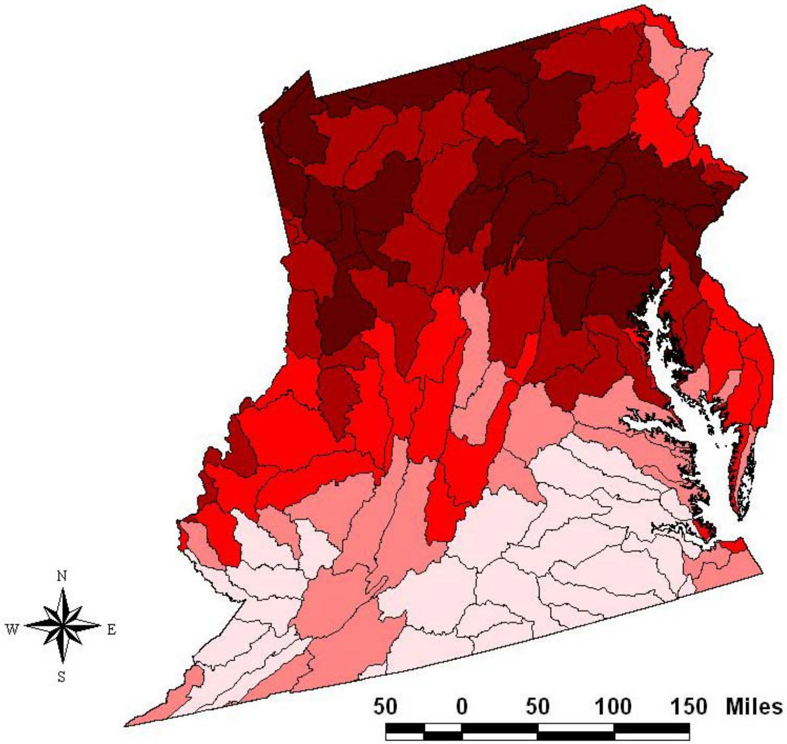
Nitrogen Yield Change for MAIA 1970s to 1990s based on 25km2 grid cells





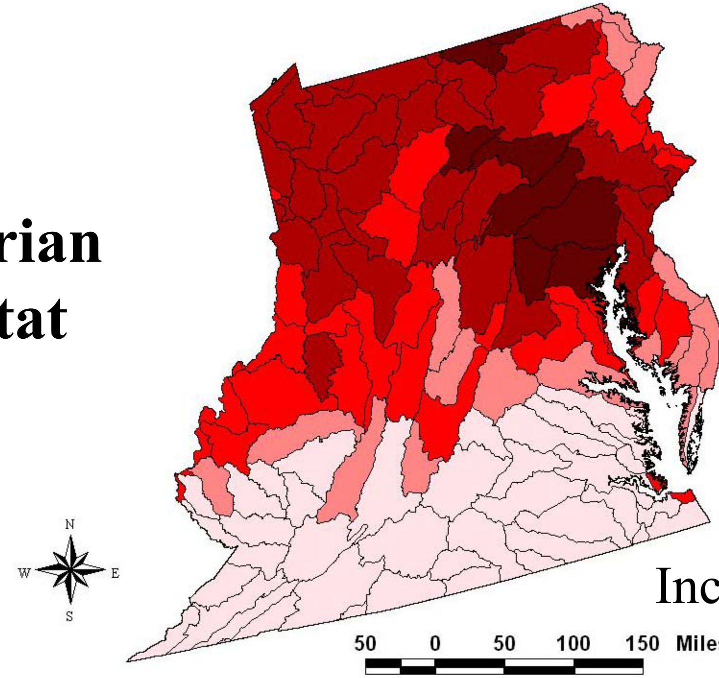
Alternative Future Assessments

Riparian Habitat

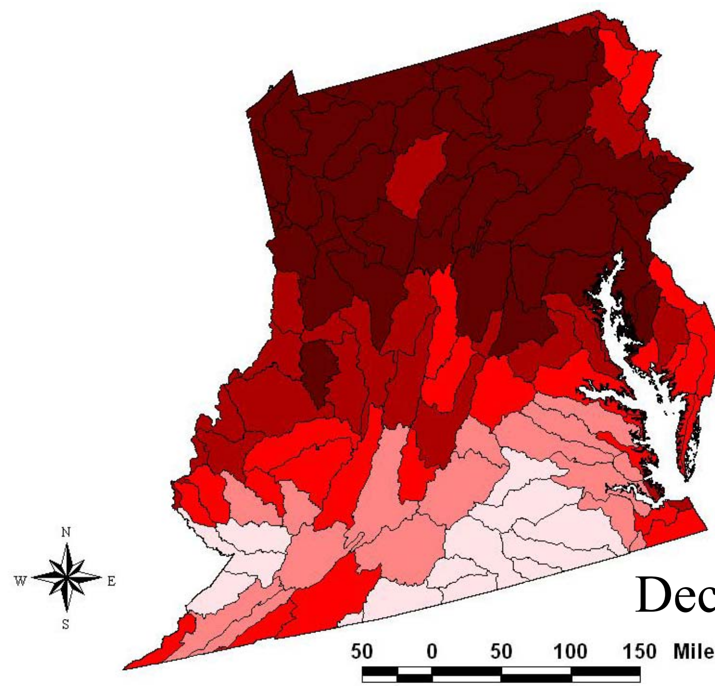


Nitrogen loadings (lbs/acre/year) as predicted by current conditions

- 0.989 - 1.812
- 1.812 - 2.738
- 2.738 - 4.52
- 4.52 - 7.356
- 7.356 - 16.904



Increase

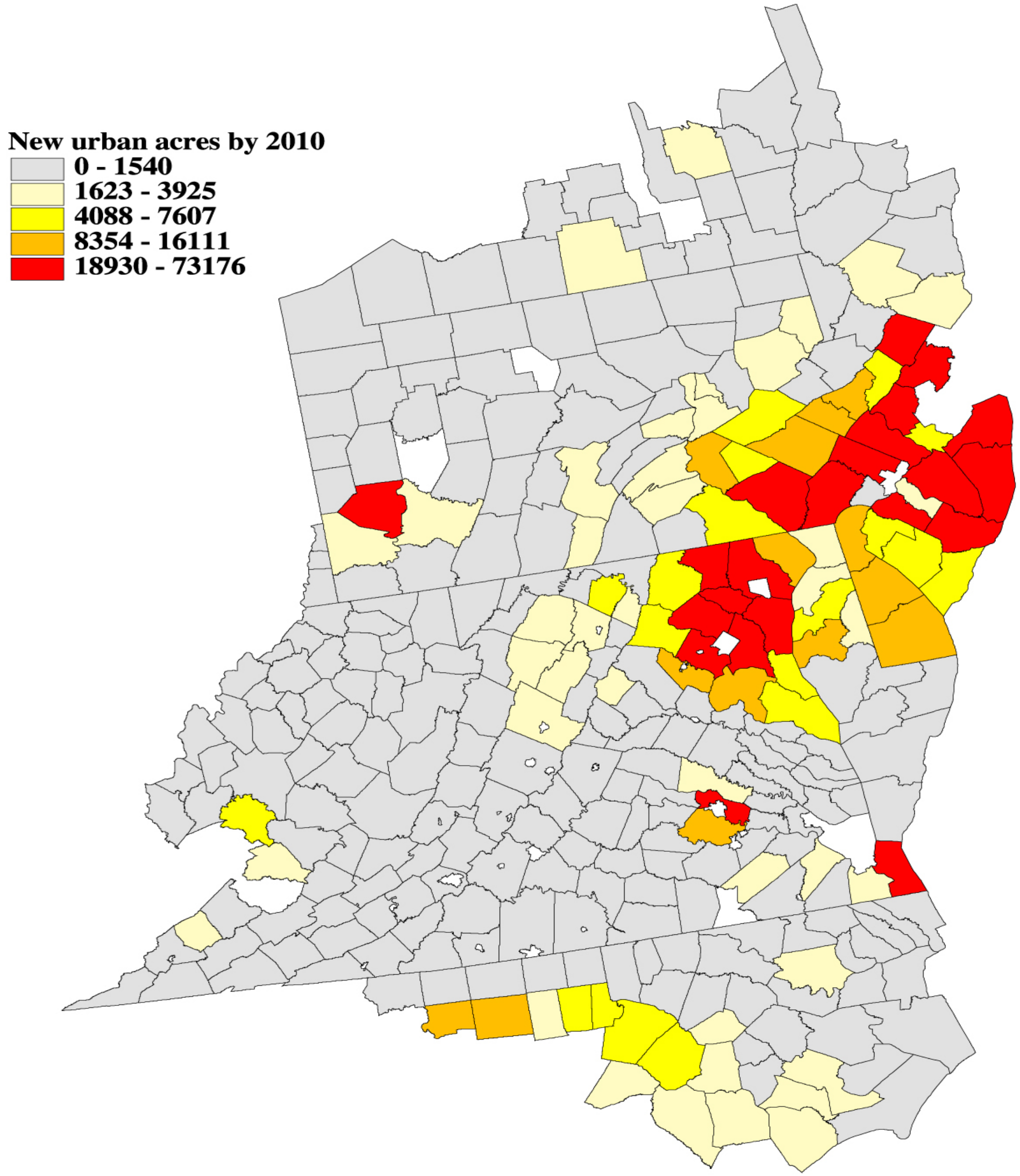


Decrease

ReVA

US EPA Office of Research and Development

PROJECTED CHANGE IN URBAN ACREAGE to 2010
from Resource Economics Model



US EPA Office of Research and Development

Analysis by Dave Wear, USDA Forest Service, and Ron Matheny, U.S. EPA (Research Triangle Park, NC)

TOOLS

Conceptual Design of AGWA

Processes

Build GIS Database

Discretize Watershed
f (topography)

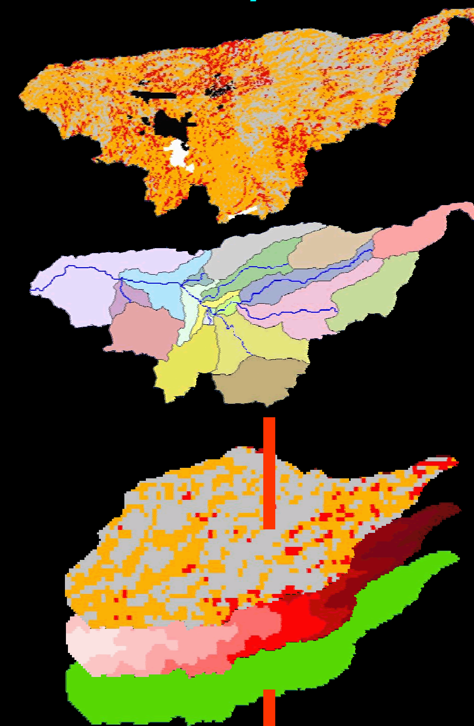
Characterize Model Elements
f (landcover, topography, soils)

Derive Secondary Parameters
look-up tables

Build Model Input Files

View Model Results
link model to GIS

Components

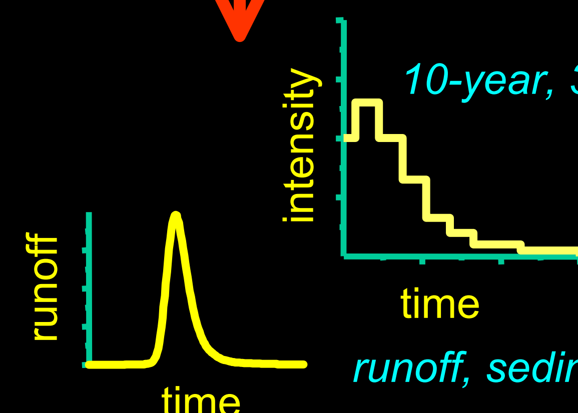


STATSGO
NALC, MRLC
USGS 7.5' DEM

Contributing
Source Area

Gravelly loam Soil

- Ks = 9.8 mm/hr
- G = 127 mm
- Por. = 0.453



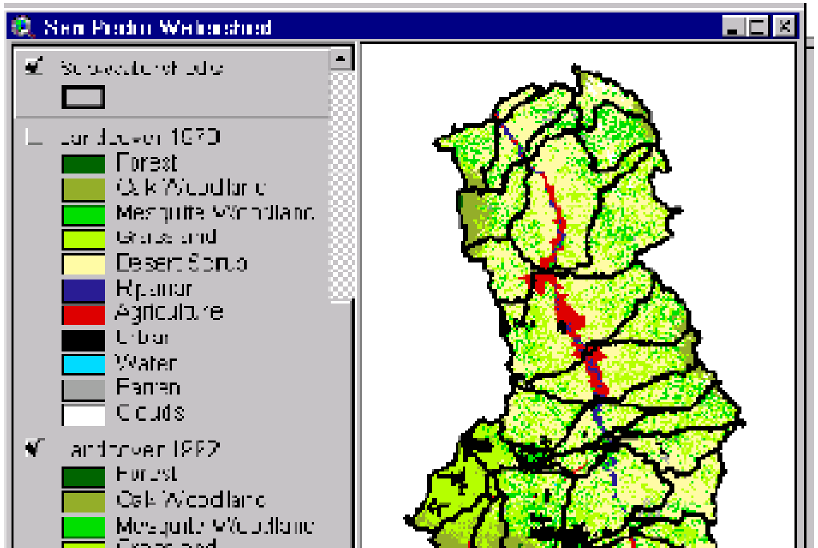
10-year, 30-minute event

runoff, sediment hydrograph

ATtILA

Analytical Tools Interface for Landscape Assessments

Environmental management practices are trending away from simple, local-scale assessments toward complex, multiple-stressor regional assessments. Landscape ecology provides the theory behind these assessments while geographic information systems (GIS) supply the tools to implement them. A common application of GIS is the generation of landscape metrics, which are quantitative measurements of the environmental condition or vulnerability of an area (e.g., ecological region or watershed). The generation of these metrics can be a complex, lengthy undertaking, requiring substantial GIS expertise.



The Landscape Ecology Branch in cooperation with U.S. EPA Region 4 and TVA are developing a user friendly interface to facilitate this process. ATtILA is an easy to use ArcView extension that calculates many commonly used landscape metrics. By


The End